Radiological Health Data

VOLUME V, NUMBER 8

AUGUST 1964

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data is published by the Public Health Service on a monthly basis. Data are provided to the Division of Radiological Health by other Federal agencies, State health departments, and foreign governments. Pertinent original data and interpretive papers are invited from investigators. Accepted material will be appropriately credited. The reports are reviewed by a Board of Editorial Advisors with representatives from the following Federal agencies:

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is widely used as the basis of alerting systems for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form and are also shown by beta concentration isograms in figure 5.

1. Radiation Surveillance Network, April 1964

Division of Radiological Health, Public Health Service

Surveillance of atmospheric radioactivity in the United States in conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health which gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The alerting function of the Network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to eliminate interference from naturally-occurring radon daughters. The Network station operators regularly report their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C. These field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are reported, appropriate Federal and State officials are notified.

Air

Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter 4-inches in diameter. A volume of about 1800 cubic meters of air is drawn through the filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, and the gross beta activity measured using a thin-window, gas-flow proportional

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, APRIL 1964

counter, calibrated with a 38,700–pc Sr^{90}–Y^{90} standard.[1] Each filter is counted at least 3 days after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated,[2] and the activity extrapolated to the time of collection.[3] The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*1*).

The Network's highest activity during April was observed on the Cheyenne, Wyoming April 23rd sample. The twenty samples with the highest activities during April are listed in table 1, giving the gross beta concentration and estimated age for each.

The April 1964 average gross beta concentration in air for each station is given in table 2. The Network average for April (1.56 pc/m³) showed a slight decrease over the March aver-

TABLE 1.—GROSS BETA ACTIVITY AND AGE OF THE TWENTY INDIVIDUAL RSN AIR FILTERS HAVING HIGHEST ACTIVITIES DURING APRIL 1964

Station		Date April	Concentration (pc/m³)	Age (days)
Colo:	Denver	23	5.12	>100
Miss:	Jackson	28	5.58	>100
Nev:	Las Vegas	11	7.29	>100
		12	5.64	>100
		13	5.49	>100
		27	5.63	>100
		29	5.86	>100
N. Mex:	Santa Fe	12	5.92	>100
		13	5.19	>100
Ore:	Portland	29	5.03	>100
Tex:	Austin	6	5.02	>100
		15	5.41	>100
		27	7.44	>100
		28	5.16	>100
		29	5.42	>100
Wyo:	Cheyenne	23	7.76	>100
		24	5.23	>100
		25	5.35	>100
		26	5.39	>100
		28	5.06	>100

[1] The Sr^{90}–Y^{90} source currently used as a standard was used from April 1962 to August 1963 as 40,000 pc total activity. Beginning with September 1963 data, the nominal activity of the standard was adjusted for decay (about 2½ percent per year) to 38,700 pc.

[2] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value and cannot be used for estimating date of formation.

[3] The Way-Wigner formula is $AT^{1.2}=C$, where A is the activity, T is the time (in any time unit) after fission product formation, and C is a constant equal to the activity at T=1.

TABLE 2.—GROSS BETA ACTIVITY IN AIR AND PRECIPITATION, APRIL 1964

Station location		Air surveillance					Precipitation measurements	
		Number of samples	Gross beta activity (pc/m³)			Last profile in *RHD*	Average concentration (pc/liter) [b]	Total deposition [b] (mc/m²)
			Maximum	Minimum	Average [a]			
Alabama:	Montgomery	22	3.54	0.29	1.80	Aug 64	300	118
Alaska:	Adak	26	2.44	<0.10	0.93	Nov 63	[c]	
	Anchorage	30	2.01	0.16	0.75	Jul 64	510	5.3
	Attu	1	0.13	0.13	0.13	Dec 63		
	Fairbanks	26	1.82	0.14	0.87	Aug 64	310	5.6
	Juneau	26	2.12	<0.10	0.57	Sep 63	290	61.2
	Kodiak	18	2.63	<0.10	0.70	Oct 63		
	Nome	14	0.77	<0.10	0.43	Feb 64		
	Point Barrow	30	1.08	0.33	0.66	Jan 64		
	St. Paul Island	29	2.14	0.11	0.85	Mar 64		
Ariz:	Phoenix	30	4.83	1.31	2.59	Sep 63	[d]—	
Ark:	Little Rock	28	4.37	1.03	2.15	Sep 63	320	87.3
Calif:	Berkeley	22	2.26	0.27	1.08	Oct 63	300	2.8
	Los Angeles	22	2.78	0.71	1.81	Feb 64	1,360	22.0
Canal Zone:	Ancon	16	1.61	<0.10	0.67	Apr 64		
Colo:	Denver	25	5.12	0.34	2.38	Nov 63	—	—
Conn:	Hartford	30	2.65	0.17	1.40	Oct 63	600	46.5
Del:	Dover	21	2.68	0.20	1.71	Aug 64	—	—
D. C:	Washington	30	3.21	0.14	1.58	Apr 64	290	106.0
Fla:	Jacksonville	30	4.16	0.79	2.23	Oct 63	210	10.9
	Miami	30	4.06	0.44	1.80	Feb 64	370	43.9
Ga:	Atlanta	0				Jul 64	—	—
Guam:	Agana	30	2.66	<0.10	0.60	Apr 64		
Hawaii:	Honolulu	30	1.76	0.34	0.93	Feb 64	500	13.5
Idaho:	Boise	26	2.84	0.50	1.47	Dec 63	510	10.4
Ill:	Springfield	27	2.79	0.30	1.61	Mar 64	910	50.3
Ind:	Indianapolis	26	3.35	0.58	1.70	Jul 64	810	129.0
Iowa:	Iowa City	28	2.84	0.33	1.48	Jan 64	540	46.9
Kans:	Topeka	21	3.27	0.63	1.61	Jul 64	640	94.9
Ky:	Frankfort	28	3.02	0.64	1.92	Feb 64	680	44.0
La:	New Orleans	29	2.54	0.40	1.56	Mar 64	250	67.7
Maine:	Augusta	29	3.11	0.17	1.67	Mar 64	460	46.2
	Presque Isle	29	2.25	<0.10	1.38	Nov 63	800	9.3
Md:	Baltimore	21	2.46	<0.10	1.25	Nov 63	1,060	74.2
	Rockville	5	2.14	<0.10	1.60	Mar 64		
Mass:	Lawrence	29	2.75	0.16	1.41	Aug 64	1,250	117.0
	Winchester	29	2.36	0.22	1.28	Apr 64	710	61.3
Mich:	Lansing	28	3.82	0.13	1.89	Feb 64	760	80.4
Minn:	Minneapolis	29	3.39	0.11	1.43	Mar 64	660	45.1
Miss:	Jackson	26	5.58	0.80	2.93	Apr 64	400	103.0
	Pascagoula					Dec 63	—	—
Mo:	Jefferson City	30	2.38	0.47	1.46	Jul 64	450	56.0
Mont:	Helena	28	2.78	<0.10	1.22	Nov 63	820	17.9
Nebr:	Lincoln	16	4.87	0.33	1.61	Apr 64	—	—
Nev:	Las Vegas	23	7.29	0.56	2.90	Aug 64	—	—
N. H:	Concord	18	2.96	0.18	1.72	Feb 64	—	—
N. J:	Trenton	30	3.03	0.18	1.43	Apr 64	940	29.5
N. Mex:	Santa Fe	28	5.92	0.64	2.38	Dec 63	740	24.8
N. Y:	Albany	22	2.03	0.23	1.18	Jul 64	340	15.6
	Buffalo	10	2.35	0.35	1.64	Nov 63		
	New York	30	2.81	0.27	1.45	Dec 63	—	—
N. C:	Gastonia	30	3.60	<0.10	1.88	Jan 64	290	28.8
N. Dak:	Bismarck	28	3.16	0.16	1.64	Feb 64	760	59.3
Ohio:	Cincinnati	22	2.89	0.67	1.66	Aug 64	—	—
	Columbus	30	4.10	0.27	1.73	Apr 64	880	142
	Painesville	30	4.11	0.50	2.13	Oct 63	1,260	113
Okla:	Oklahoma	27	3.80	0.12	2.08	Apr 64	<200	<2.0
	Ponca City	27	2.13	<0.10	1.07	Oct 63	550	20.2
Ore:	Portland	29	5.03	0.45	1.96	Oct 63	330	14.6
Pa:	Harrisburg	29	1.91	0.11	0.80	Jul 64	580	44.7
P. R:	San Juan	29	2.01	0.53	1.07	Mar 64	270	17.1
R. I:	Providence	27	3.15	0.40	1.78	Jan 64	430	22.7
S. C:	Columbia	29	3.38	0.31	1.83	Dec 63	440	43.7
S. Dak:	Pierre	30	2.85	0.22	1.47	Sep 63	340	38.8
Tenn:	Nashville	26	3.84	0.18	2.04	Jan 64	540	61.9
Tex:	Austin	29	7.44	0.60	2.76	Aug 64	370	13.2
	El Paso	29	4.19	0.94	2.53	Jan 64	2,800	3.0
Utah:	Salt Lake City	30	3.59	0.26	1.85	Aug 63	660	57.1
Vt:	Barre	29	3.65	<0.10	1.73	Sep 63	290	21.7
Va:	Richmond	27	2.22	0.25	1.21	Sep 63	680	49.6
Wash:	Seattle	30	1.59	0.16	0.70	Jul 64	680	15.5
W. Va:	Charleston	29	4.02	0.43	1.87	Dec 63	1,190	90.3
Wisc:	Madison	29	4.00	0.28	1.70	Sep 63	450	42.8
Wyo:	Cheyenne	29	7.76	0.16	2.95	Aug 64	600	14.0
Network summary		1865	7.76	<0.10	1.56			

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] The minimum concentration reported for a single sample is 200 pc/liter. If the individual sample has a concentration of <200 pc/liter, the deposition for that sample is calculated by $D=\frac{C\times P}{1000}=<0.2$: in mc/m² (see text). A less-than sign (<) is used with the monthly total deposition whenever the sum of the individual less-than values represents more than 10 percent of the total. The monthly average concentration is then calculated as described in text, retaining the less-than sign when used with the total deposition.

[c] Blank space indicates no sample collected.

[d] Dash indicates no evaporated sample received.

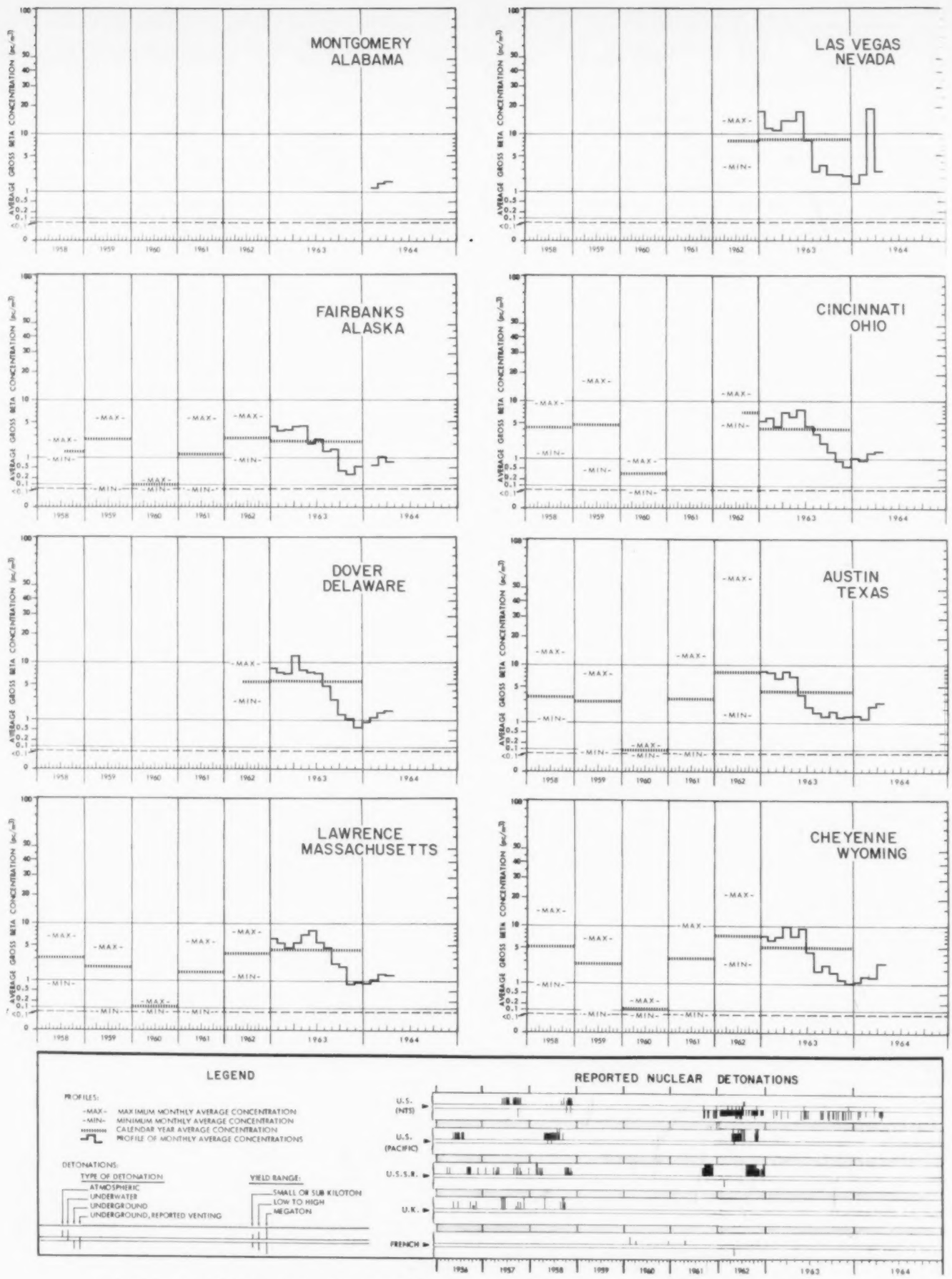

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1958—APRIL 1964

age (1.60 pc/m³). Table 1, however, gives evidence that the activity due to the "spring rise" (activity injected from stratosphere during the spring months) showed an increase in April over that in March. The twenty highest samples in April ranged from 5.02 to 7.76 pc/m³—all having an age of >100 days. In March, the twenty highest samples ranged from 3.80 to 473 pc/m³. If the samples showing fresh fission products during March were disregarded, the highest 20 samples would have ranged between 3.80 and 5.21. Therefore, the range of old fission products in April appears to be distinctly higher than the corresponding range in March.

Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500–ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nc/m², C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C} = \frac{\Sigma D}{\Sigma P} \times 1000$$

The April 1964 average concentrations and total depositions are given in table 2.

2. Canadian Air Monitoring Program,[1] April 1964

Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas-flow, Geiger-Mueller counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for April 1964 are given in table 3 and presented in conjunction with U. S. and Mexican data by an isogram map (figure 5).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

[1] Data from *Radiation Protection Programs 4:* 11–24, Radiation Protection Division, Canadian Department of National Health and Welfare (May 1964).

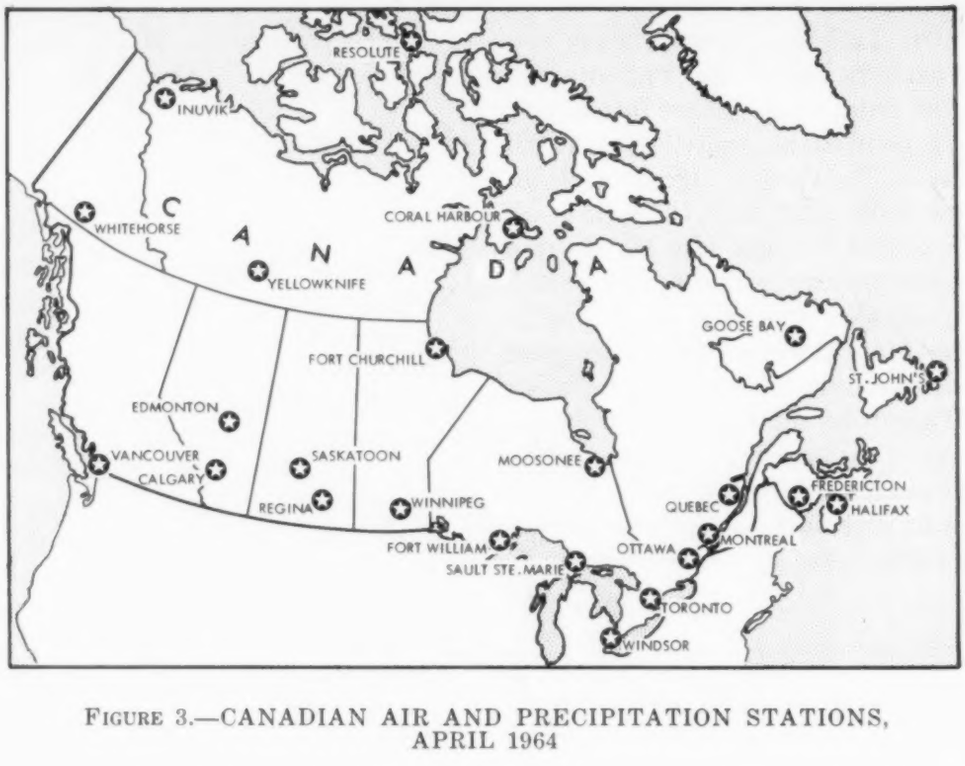

FIGURE 3.—CANADIAN AIR AND PRECIPITATION STATIONS, APRIL 1964

TABLE 3.—GROSS BETA ACTIVITY IN AIR, CANADA, APRIL 1964

[Concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	28	3.7	0.5	1.7
Coral Harbour	30	1.9	0.5	1.2
Edmonton	30	3.1	0.5	1.3
Ft. Churchill	30	2.6	0.5	1.3
Ft. William	29	3.5	0.1	1.5
Fredericton	29	2.6	0.1	1.4
Goose Bay	30	2.6	0.5	1.5
Halifax	29	3.6	0.1	1.6
Inuvik	29	2.3	0.9	1.5
Montreal	30	3.5	0.1	1.6
Moosonee	29	2.9	0.3	1.7
Ottawa	30	2.9	0.1	1.4
Quebec	30	2.9	0.1	1.5
Regina	30	3.7	0.7	1.8
Resolute	30	2.8	0.6	1.4
St. John's, Nfld	30	2.6	0.1	1.1
Saskatoon	30	3.3	0.9	1.7
Sault Ste. Marie	30	2.7	0.2	1.4
Toronto	30	3.0	0.2	0.7
Vancouver	30	1.9	0.2	0.9
Whitehorse	30	2.6	0.2	0.9
Windsor	28	3.9	0.5	1.8
Winnipeg	30	3.1	0.5	2.0
Yellowknife	30	2.4	0.6	1.5
Network summary	711	3.9	0.1	1.4

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for April 1964 samples are given in table 4. Radionuclide analyses appear quarterly.

TABLE 4.—GROSS BETA ACTIVITY IN PRECIPITATION, CANADA, APRIL 1964

Station	Total beta activity	
	pc/liter	nc/m²
Calgary	1,080	14.2
Coral Harbour	678	4.5
Edmonton	1,500	28.6
Ft. Churchill	905	11.0
Ft. William	749	102.4
Fredericton	531	53.6
Goose Bay	1,256	30.6
Halifax	641	74.5
Inuvik	491	4.0
Montreal	696	43.1
Moosonee	1,059	41.6
Ottawa	746	48.8
Quebec	778	42.6
Regina	2,695	15.7
Resolute	128	10.7
St. John's, Nfld	373	36.6
Saskatoon	[a] —	—
Sault Ste. Marie	1,080	59.2
Toronto	—	—
Vancouver	1,104	39.3
Whitehorse	393	5.0
Windsor	862	92.9
Winnipeg	734	39.8
Yellowknife	855	6.5
Average	879	36.6

[a] Dash indicates no sample collected.

3. Mexican Air Monitoring Program April 1964

National Commission of Nuclear Energy

As part of its Radiological Protection Program (RPP), the Comisión Nacional de Energía Nuclear (CNEN) established the Radiation Surveillance Network of Mexico to provide a means for determining increased levels of radioactivity in air and precipitation.

The network has been gradually expanded to 17 stations (see figure 4). Twelve of the 17 stations are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí and Ensenada; Staff Members of the RPP operate the station at Mexico City while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Instituto de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day, through a high-efficiency glass fiber filter, 6″ x 8″, using high volume samplers. After each 24-hour period, the filter is removed and forwarded via air mail to the 'Laboratorio de Estudios Sobre Contaminación Radiactiva," CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughters' natural radioactivity. Data are not extrapolated to time of collection.

The maximum, minimum and average fission product beta concentrations in surface air during April 1964 are presented in table 5.

TABLE 5.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, APRIL 1964

[Concentrations in pc/m³]

Station	Number of Samples	Maximum	Minimum	Average
Acapulco [a]	—	—	—	—
Ciudad Juárez	22	4.0	0.6	2.1
Chihuahua	19	6.3	1.1	3.0
Ensenada	13	3.6	0.6	1.8
Guadalajara	15	1.0	0.2	0.6
Guaymas	18	2.1	0.1	1.0
La Paz	17	4.4	1.0	2.2
Matamoros [a]	—	—	—	—
Mazatlán	17	3.8	1.2	2.4
Mérida	20	2.1	0.2	0.8
México, D.F.	19	0.8	0.1	0.3
Nuevo Laredo	4	2.3	0.4	—
San Luis Potosí	13	1.0	0.3	0.6
Tampico	9	1.0	0.5	0.7
Torreón	16	5.1	0.5	1.7
Tuxtla Gutiérrez [a]	—	—	—	—
Veracruz	13	1.4	0.3	0.7
Network summary	215	6.3	0.1	1.4

[a] Temporarily shut down.

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

4. Pan American Air Sampling Program April 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by three countries in South America under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS) for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The four air sampling stations included in the program are operated by technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; and in Santiago, Chile, by the Occupational Health Service. The Kingston station began operation in March 1964; the others were started in the latter part of 1962.

The April 1964 air monitoring results from the four participating countries are given in table 6. The Caracas and Jamaica stations, included in figure 5 with the April averages adjusted by the RSN intercalibration factor,[5] were used in positioning the beta concentration isograms.

TABLE 6.—GROSS BETA ACTIVITY IN AIR, APRIL 1964

[Concentrations in pc/m³]

Sampling stations	No. of samples	Maximum	Minimum	Average [a]
Kingston, Jamaica	25	1.35	0.30	0.74
Caracas, Venezuela	21	1.89	0.27	0.68
Lima, Peru	8	0.12	<0.10	<0.10
Santiago, Chile	18	0.18	<0.10	<0.11

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

[5] The RSN factor is 1.28.

5. Gross Beta Activity in Air, North America April 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America.[6] The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*8*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*9*). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963.

Figure 5 shows the April 1964 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network and Mexican Air Monitoring program. An intercalibration factor of 1.28 was applied to the RSN data and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

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[6] The January 1963 through February 1964 isogram maps were published in the May 1963 through June 1964 issues of *Radiological Health Data*.

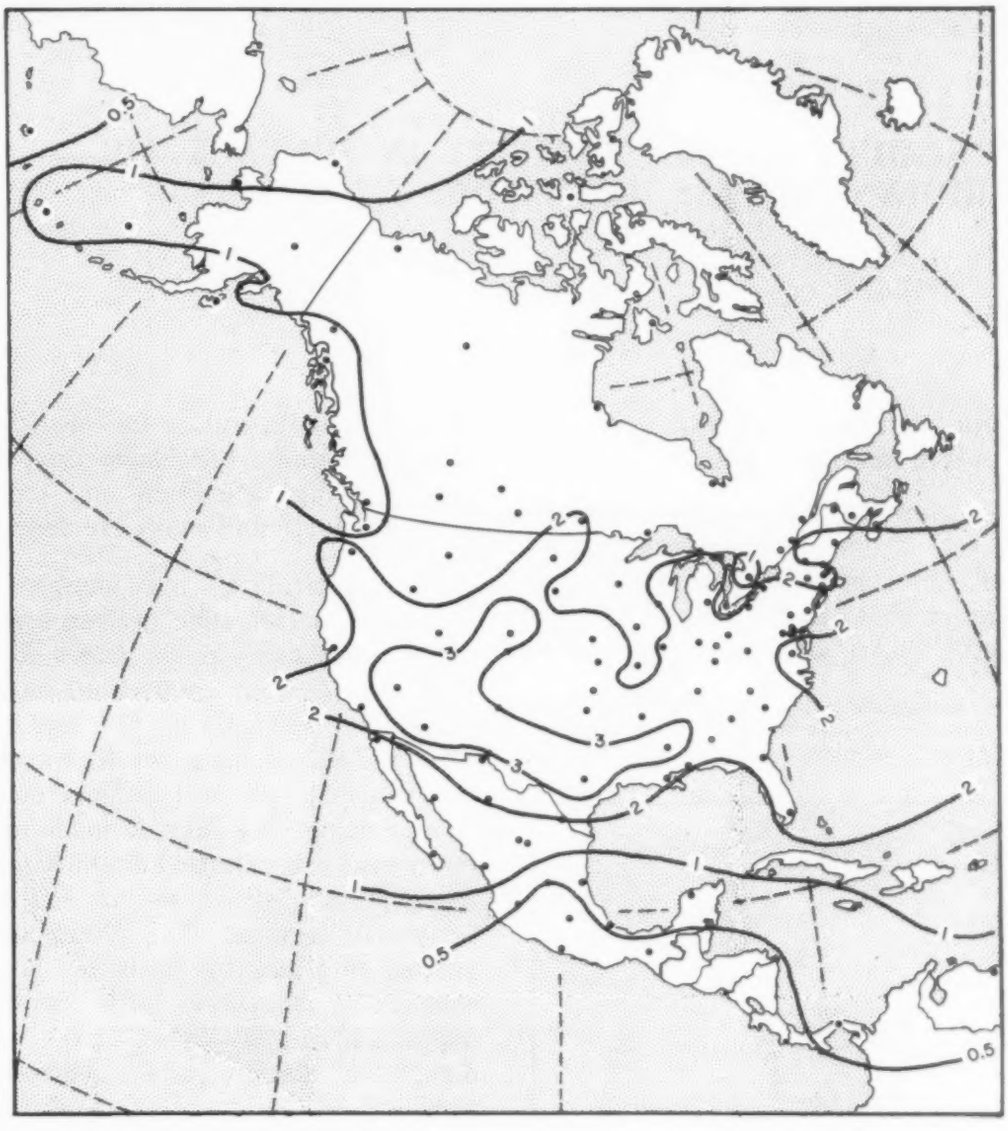

FIGURE 5.—ISOGRAMS OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR THROUGHOUT NORTH AMERICA (pc/m³), APRIL 1964

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(7) Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, RPD–21*, Department of National Health and Welfare, Ottawa, Canada (August 1962).

(8) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Naval Research Laboratory, Washington, D. C. 20390 (November 13, 1962); abstracted in *Radiological Health Data*, December 1962.

(9) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of the Major North American Networks Employed in Monitoring Airborne Fission Products, NRL Report 6025*, Naval Research Laboratory, Washington, D. C. 20390 (December 1963); summarized in *Radiological Health Data*, January 1964.

FISSION PRODUCT GAMMA ACTIVITY IN SURFACE AIR— 80TH MERIDIAN AND U.S. LOCATIONS

William R. Collins, Jr.[1]

80th Meridian Network, March and April 1964

Fourteen air sampling stations near the 80th Meridian (West) from Thule, Greenland, to Punta Arenas, Chile, make up the Health and Safety Laboratory (HASL) 80th Meridian Network (figure 1). An additional station at Mauna Loa, Hawaii, is included for comparing data with that from Chacaltaya, Bolivia; both are at a high elevation and their respective latitudes north and south are nearly equal.

[1] Mr. Collins is a chemist on the staff of the Environmental Studies Division, Health and Safety Laboratory, U. S. Atomic Energy Commission.

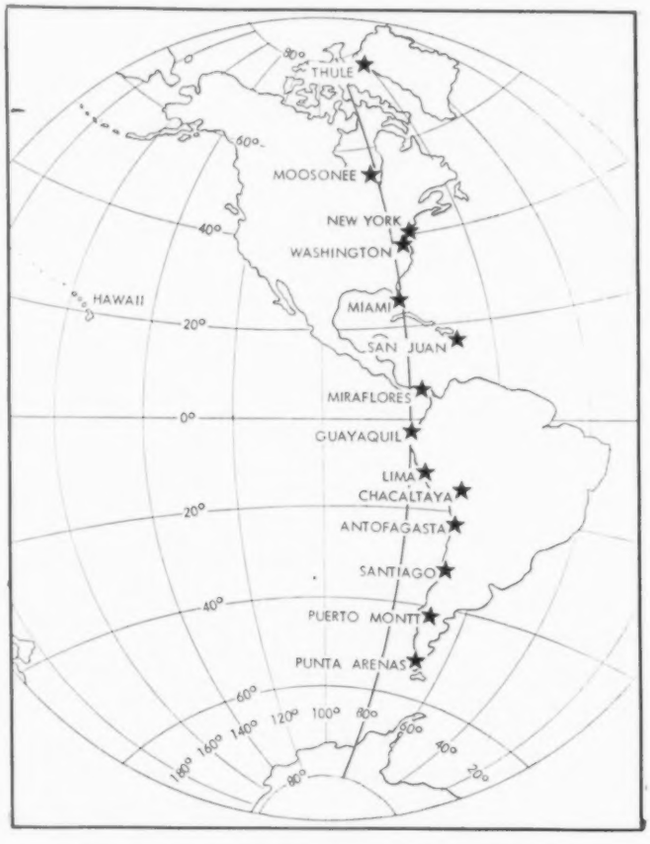

FIGURE 1.—80TH MERIDIAN NETWORK SAMPLING STATIONS (6 NEW U. S. STATIONS NOT SHOWN)

Air particulates are sampled on 8-inch-diameter polystyrene (Microsorban) filters, drawing air through the filters continuously at the rate of about 1400 cubic meters per day. Filters are changed on the 1st, 8th, 15th and 22nd of each month and forwarded to HASL for analysis. A total gamma count over the energy range, 0–3 Mev, is made approximately two weeks after the end of the sampling period, using an 8 x 4-inch sodium iodide (thallium-activated) crystal. The filters are then composited on a monthly basis and analyzed radiochemically, together with monthly ground deposition samples taken at the same site, for detectable fission and neutron activation products.

The results of total gamma activity determinations in weekly ground level air filter samples taken at 80th Meridian stations during March and April 1964 are listed in tables 1 and 2, together with average monthly activity concentrations calculated for each site. The average monthly activities are also plotted in figure 2 as activity-latitude profiles.

The monthly averages for all of the northern sites were 0.77, 0.85, 0.99 and 0.97 $\gamma/min/m^3$, respectively, for January through April. The corresponding averages in the Southern Hemisphere were 0.055, 0.051, 0.063, and 0.048 $\gamma/min/m^3$. The data appear to follow the pattern of the usual spring rise in the Northern Hemisphere.

TABLE 1.—GAMMA ACTIVITY IN SURFACE AIR, 80TH MERIDIAN NETWORK, MARCH 1964

[Activity in gamma photons/min/m³]

Station latitude, elevation	March sampling periods				March average
	1–7	8–14	15–21	22–31	
Thule, Greenland 77° N, 259 m	0.693	0.983	0.947	1.08	0.940
Moosonee, Canada 51° N, 10 m	0.850	0.765	0.961	1.01	0.911
New York, N. Y. 41° N, 38 m	0.793	1.39	0.990	1.11	1.03
Washington, D. C. 39° N, 82 m	0.974	1.23	1.14	1.30	1.17
Miami, Fla. 26° N, 4 m	1.91	1.24	1.30	1.75	1.60
Mauna Loa, Hawaii 19° N, 3394 m	0.592	0.506	0.881	0.768	0.701
San Juan, P. R. 18° N, 10 m	1.87	0.314	0.722	0.221	0.724
Miraflores, Canal Zone 9° N, 10 m	0.755	0.852	0.268	1.38	0.859
Guayaquil, Ecuador 0°-08′ S, 7 m	0.131	0.357	0.148	0.106	0.185
Lima, Peru 12° S, 50 m	0.0796	0.113	0.0624	0.0577	0.0768
Chacaltaya, Bolivia 17° S, 5220 m	0.0200	0.0260	0.00946	0.0219	0.0196
Antofagasta, Chile 24° S, 519 m	0.0397	0.0791	0.0572	0.0435	0.0539
Santiago, Chile 33° S, 5 m	0.0406	0.0644	0.0357	0.0569	0.0499
Puerto Montt, Chile 41° S, 5 m	0.0424	0.0270	0.0369	0.0330	0.0346
Punta Arenas, Chile 53° S, 3 m	0.0163	0.0181	0.0192	0.0103	0.0155

TABLE 2.—GAMMA ACTIVITY IN SURFACE AIR, 80TH MERIDIAN NETWORK, APRIL 1964

[Activity in gamma photons/min/m³]

Station latitude, elevation	April sampling periods				April average
	1–7	8–14	15–21	22–31	
Thule, Greenland 77° N, 259 m	1.09	1.18	1.13	0.894	1.06
Moosonee, Canada 51° N, 10 m	1.05	1.08	1.10	1.06	1.07
New York, N. Y. 41° N, 38 m	0.957	1.55	0.432	1.03	1.00
Washington, D. C. 39° N, 82 m	0.981	1.55	1.10	0.412	0.972
Miami, Fla. 26° N, 4 m	1.57	0.750	2.02	0.846	1.26
Mauna Loa, Hawaii 19° N, 3394 m	0.857	1.28	0.546	0.866	0.887
San Juan, P. R. 18° N, 10 m	0.655	0.834	0.942	0.747	0.791
Miraflores, Canal Zone 9° N, 10 m	1.16	0.655	0.714	0.148	0.633
Guayaquil, Ecuador 0°-08′ S, 7 m	0.139	0.0769	0.0856	0.0510	0.0832
Lima, Peru 12° S, 30 m	0.0972	0.0117	0.0610	0.0500	0.0549
Chacaltaya, Bolivia 17° S, 5220 m	0.0376	0.0318	0.0225	0.0227	0.0281
Antofagasta, Chile 24° S, 519 m	0.0589	0.0506	0.0501	0.0588	0.0549
Santiago, Chile 33° S, 5 m	0.0885	0.0749	0.0393	0.0321	0.0577
Puerto Montt, Chile 41° S, 5 m	0.0454	0.0457	0.0228	0.0313	0.0359
Punta Arenas, Chile 53° S, 3 m	0.0198	0.0218	0.0197	0.0103	0.0174

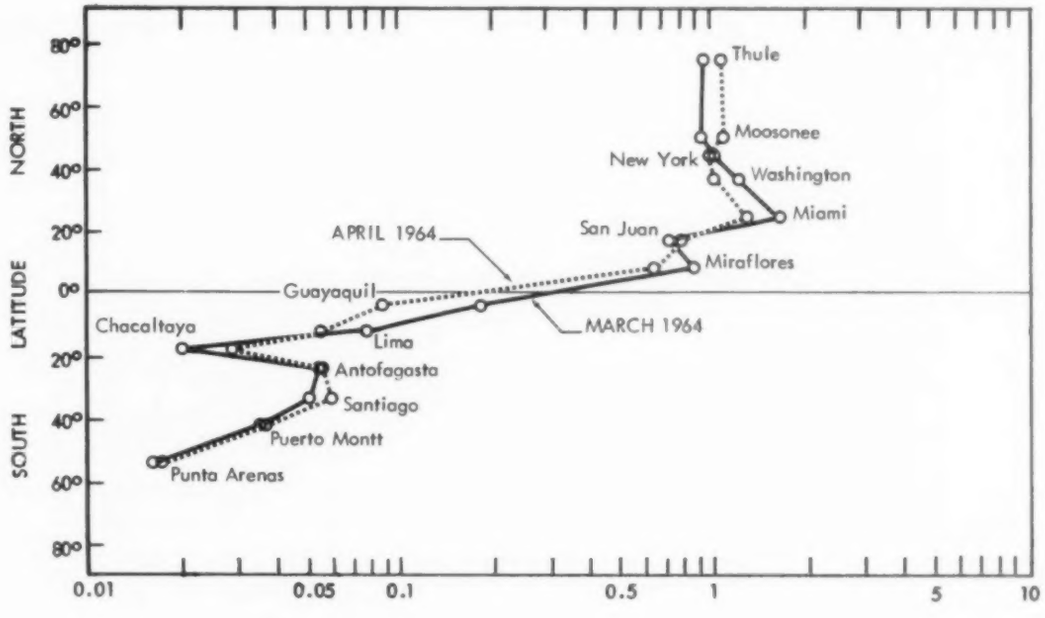

FIGURE 2.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, MARCH AND APRIL 1964

Additional United States Sites

Since August 1963 the following sites have been added to the HASL ground level air sampling network:

	Longitude	*Latitude*	*Elevation*
Westwood, N.J.	74°01′W	41°00′N	38 m
Chattanooga, Tenn.	85°20′W	35°03′N	206 m
Appleton, Wis.	88°25′W	44°15′N	229 m
Midwest City, Okla.	97°30′W	35°25′N	364 m
Seattle, Wash.	122°20′W	47°36′N	3 m
Palo Alto, Calif.	122°23′W	37°30′N	19 m

As with the original 80th Meridian sites, both air filter and deposition samples are taken at the new stations using the equipment and methods described above.

The actual maintenance of the new sites and individual radionuclide determinations are performed by Food, Chemical and Research Laboratories, Inc. of Seattle for the Seattle site, by Hazelton-Nuclear Science Corporation of Palo Alto for the Palo Alto and Midwest City sites and by Isotopes, Inc. of Westwood for the Westwood, Chattanooga and Appleton sites. Deposition data from these sources are reported in the HASL Fallout Program Quarterly Summary Reports. The surface air data will be reported as it becomes available in the monthly 80th Meridian reports.

Average monthly total gamma activity concentrations calculated from data received for weekly samples taken at the new sites from August 1963 through April 1964 are given in table 3. These data are in fair agreement with total gamma activity measurements previously reported for 80th Meridian sites at similar latitudes, indicating that latitude had no great effect on ground level air activity concentrations in the United States during the period of observation covered by the data. The data in table 3 also reflect the usual spring increases in the Northern Hemisphere with concentrations averaging 0.91, 0.87, 1.05, and 1.22 γ photons/min/m^3 for the January through April 1964 period.

TABLE 3.—GAMMA ACTIVITY IN SURFACE AIR, UNITED STATES SITES

[Activity in γ photons/min/m^3]

Station	August 1963	September 1963	October 1963	November 1963	December 1963	January 1964	February 1964	March 1964	April 1964
Westwood	4.53	1.96	1.58	0.782	0.625	0.645	0.934	0.964	1.07
Chattanooga	5.25	2.14	1.93	0.840	0.676	0.844	0.666	1.02	1.45
Appleton	5.07	1.67	1.54	0.690	0.527	0.580	0.690	1.03	0.947
Midwest City	5.64	2.17	2.82	2.53	1.78	1.51	1.22	1.73	1.95
Seattle	1.74	1.25	1.31	0.757	1.09	0.620	0.612	0.492	0.662
Palo Alto	4.33	2.27	2.84	1.42	1.28	1.28	1.10	1.04	1.24

MONTHLY DEPOSITION OF VARIOUS RADIONUCLIDES

For the purpose of this section the word "fallout" refers to the deposition of radioactive materials on the earth's surface, normally expressed in terms of the activity of selected radionuclides deposited on a unit area during a given period of time. Unless otherwise stated, fallout measurements include both precipitation and dry fallout (settled dust).

Reports of fallout measurements at selected stations in North and South America are presented below.

1. Fallout in the United States and Other Areas[1] July–December 1963

Health and Safety Laboratory
Atomic Energy Commission

Monthly fallout deposition rates are determined by the Health and Safety Laboratory (HASL) for 48 sites in the United States and 104 locations in other countries. HASL data from 10 of the U. S. stations and 21 other selected points in the Western Hemisphere (see figure 1) covering the period from July through December 1963 are summarized below. All of the stations of the 80th Meridian Network are represented.

Methods of Collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of one month in stainless steel pots with exposed areas of 0.076m^2. At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

[1] The data in this article were taken from *Fallout Program Quarterly Summary Report, HASL–144:* 2–172, Health and Safety Laboratory, AEC, New York, N.Y. 10014.

FIGURE 1.—HASL FALLOUT SAMPLING LOCATIONS

The second method involves the use of a polyethylene funnel, with an exposed area of 0.072m^2 attached to an ion exchange column. After a one-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95 percent confidence level there was no significant difference in the strontium–90 measurements obtained from samples collected by the two methods (*1*).

Strontium–90

All of the HASL fallout samples—both pot and column—were assayed for strontium–90 and strontium–89. The strontium–90 data are given in tables 1 and 2 for 58 selected stations. Where duplicate samples were collected, the average values are given.

Other Radionuclides

Laboratories at Westwood, New Jersey; Chattanooga, Tennessee; Seattle, Washington; and Appleton, Wisconsin have analyzed duplicate monthly pot samples for various radionuclides. The monthly deposition rates for Sr^{89}, Sr^{90}, Ce^{144}, Cs^{137}, Zr^{95}, Mn^{54} and precipitation depth are presented in table 3.

TABLE 1.—MONTHLY STRONTIUM–90 FALLOUT IN THE UNITED STATES, HASL, JULY–DECEMBER 1963

[Deposition in nc/m^2]

Sampling location and type of collection			July	August	September	October	November	December
Ala:	Birmingham	(pot)	4.94	0.88	0.51	0.13	0.05	0.77
Alaska:	Anchorage	(col)	[a]	4.00	0.63	0.32	0.12	0.19
	Barrow	(col)	[a]	[a]	0.07	0.36	0.09	0.09
	Cold Bay	(col)	2.81	2.31	1.46	0.37	0.31	0.25
	Fairbanks	(col)	2.54	1.62	0.19	0.17	0.02	0.07
	Juneau	(col)	5.07	1.40	[a]	0.37	0.41	0.91
	Nome	(col)	[a]	[a]	[a]	[a]	[a]	0.20
Calif:	W. Los Angeles	(pot)	0.046	0.11	0.45	0.27	0.42	0.03
	Palo Alto	(col)	0.0386	0.08	0.12	0.20	0.47	0.07
	Palo Alto	(pot)	[a]	[a]	[a]	[a]	0.34	0.03
	San Francisco	(col)	0.0015	0.027	0.07	0.29	0.41	0.36
Colo:	Denver	(col)	1.12	1.66	0.19	0.82	0.67	0.10
Fla:	Coral Gables	(pot)	0.64	0.59	1.47	[a]	0.35	0.43
	Miami	(col)	0.90	0.76	0.61	1.24	0.32	0.31
Hawaii:	Hilo	(col)	2.86	2.76	1.50	1.80	1.06	0.24
	Lihue	(col)	0.56	0.230	0.22	0.22	0.10	0.35
	Mauna Loa	(col)	0.39	0.18	0.16	0.03	0.02	0.23
	Oahu	(pot)	1.31	0.88	0.90	0.44	0.17	0.78
Ill:	Argonne	(pot)	3.31	0.42	0.37	0.51	0.25	0.18
La:	New Orleans	(col)	1.92	1.0	0.29	0.10	0.71	0 58
Minn:	International Falls	(col)	5.09	2.80	0.89	0.25	0.37	0.20
Mo:	Columbia	(col)	2.6	2.0	0.60	0.51	0.33	0.14
Mont:	Helena	(col)	0.18	1.21	0.67	0.72	0.12	0.16
N. J:	Westwood	(col)	5.20	2.21	2.1	0.60	0.98	0.55
	Westwood	(pot)	4.6	2.03	1.80	0.58	0.96	0.54
N. Y:	New York	(pot)	2.64	1.85	1.12	0.12	1.79	0.83
N. Dak:	Williston	(col)	1.32	0.44	0.25	0.07	0.19	0.25
Okla:	Tulsa	(pot)	2.72	1.05	[a]	0.60	[a]	0.17
Ore:	Medford	(col)	0.71	0.54	0.26	0.031	0.42	0.33
Ohio:	Wooster	(pot)	[a]	1.31	0.54	0.21	0.40	0.12
S. C:	Columbia	(col)	2.0	0.58	0.48	0.03	0.56	0.68
S. Dak:	Vermillion	(pot)	2.1	1.57	0.49	0.45	0.09	0.01
Tex:	Dallas	(col)	0.52	0.10	0.12	0.15	0.55	0.15
	El Paso	(col)	0.60	0.55	0.11	0.13	0.37	0.05
	Houston	(col)	0.72	0.30	0.20	0.14	0.60	0.96
Utah:	Salt Lake City	(pot)	0.18	0.73	0,93	0.88	0.56	0.29
Va:	Sterling	(col)	1.03	1.42	0.43	0.12	0.86	0.21
Wash:	Seattle	(pot)	1.47	0.66	0.81	1.4	1.64	1.19
	Tatoosh Island	(col)	3.2	[a]	1.7	2.9	2.22	0.12
Wis:	Green Bay	(col)	2.2	1.2	1.07	0.50	0.42	0.17

[a] Not received

TABLE 2.—MONTHLY STRONTIUM-90 FALLOUT IN NORTH AND SOUTH AMERICA—HASL, JULY–DECEMBER 1963

[Deposition in nc/m²]

Station [a]	Collection period					
	July	August	September	October	November	December
Bermuda	0.97	1.1	0.49	0.80	0.43	1.40
Bolivia:						
La Paz	0.03	0.008	0.07	0.12	0.05	0.05
Chacaltaya [b]	0.12	0.05	0.08	0.05	0.60	0.07
Brazil:						
Belem	0.05	0.08	0.08	0.09	0.01	0.09
Nova Friburgo	0.02	0.05	0.02	1.04	0.06	[c]
Rio de Janeiro	0.05	0.09	0.03	0.28	0.14	0.03
Canada:						
Ontario, Moosonee [b]	2.2	1.80	0.70	0.52	0.14	0.07
Ernest Harman AB	2.5	2.3	1.3	0.79	0.08	0.11
Goose AB	3.7	1.32	1.13	0.37	0.29	0.21
Chile:						
Antofagasta [b]	0.004	[c]	0.007	0.17	0.02	0.02
Puerto Montt [b]	0.22	0.02	0.01	0.05	[c]	0.18
Punta Arenas [b]	[c]	0.06	0.05	[c]	0.04	0.15
Santiago [b]	0.17	0.47	0.031	0.04	0.04	0.04
Colombia, Bogota	0.04	0.03	0.02	0.03	0.05	0.02
Costa Rica, Turrialba	0.35	0.17	0.14	0.29	0.13	0.26
Ecuador:						
Guayaquil [b]	0.02	0.007	0.007	0.05	0.02	0.22
Quito	0.03	0.01	0.015	0.03	[c]	0.03
Greenland, Thule	0.83	2.0	0.15	0.88	0.04	0.04
Iceland, Keflavik	0.98	0.46	1.12	1.2	0.29	Lost
Mexico, Mexico City	1.00	1.0	0.30	0.2	0.04	1.79
Canal Zone	0.37	0.32	0.11	0.11	0.57	0.10
Peru, Lima [b]	0.02	[b]	0.03	0.03	0.06	0.04
Puerto Rico, San Juan	0.84	0.84	0.72	0.12	0.39	0.20
Venezuela, Caracas	0.65	0.34	0.22	0.25	0.22	0.09

[a] All samples are from columns except at Nova Friburgo, where pot collection is done.
[b] 80th Meridian Network station.
[c] No sample received.

2. Fallout Measurements in Canada January–March 1964

Department of National Health and Welfare
Ottawa, Canada

The monthly accumulated precipitation samples collected in conjunction with the Canadian air sampling network described earlier in this issue represent total fallout (wet and dry), since they are collected in deep pots lined with polyethylene. The radiochemical analyses of these samples for January through March 1964 are given in table 4.

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(*1*) Ong, L. D. Y., Homogeneity Between Pot and Ion Exchange Column Strontium-90 Measurements, *Fallout Program Quarterly Summary Report, HASL-135:* 256–69, Office of Technical Services, Department of Commerce, Washington 25, D. C. (April 1, 1963), price $4.00.

TABLE 3.—RADIOCHEMICAL ANALYSES OF POT FALLOUT SAMPLES—HASL, JULY–DECEMBER 1963

[Deposition in nc/m²]

Location and analyses	July	August	September	October	November	December
California, Palo Alto						
Precipitation (mm)	Dry	Trace	4.57	25.15	69.59	Trace
Sr^{89}	0.70	0.92	0.15	0.14	0.30	0.02
Sr^{90}	0.15	0.33	0.11	0.14	0.34	0.03
Ce^{144}	0.32	1.64	2.71	2.29	4.71	2.03
Cs^{137}	0.05	0.20	0.25	0.34	0.74	0.22
Zr^{95}	0.11	0.50	0.68	0.61	1.03	0.27
Mn^{54}	<0.02	0.33	0.36	0.59	0.67	0.28
New Jersey, Westwood						
Precipitation (mm)	120.9	45.7	119	23.4	113.8	38.35
Sr^{89}	12.4	4.01	2.6	0.60	0.59	0.19
Sr^{90}	5.2	2.20	2.06	0.60	0.98	0.55
Ce^{144}	71.8	47.9	36.4	11.3	20.8	11.58
Cs^{137}	6.7	4.7	3.40	0.99	1.87	0.63
Zr^{95}	33.2	Lost	8.06	2.04	Lost	1.74
Mn^{54}	9.3	6.3	4.5	1.15	Lost	1.32
Oklahoma, Midwest City						
Precipitation (mm)	150.87	62.23	45.97	5.08	50.5	17.02
Sr^{89}	7.68	1.67	0.60	0.18	1.21	0.07
Sr^{90}	1.67	0.55	0.37	0.15	1.21	0.08
Ce^{144}	23.35	15.86	8.95	2.62	5.02	2.60
Cs^{137}	2.84	1.72	0.76	0.35	0.97	0.30
Zr^{95}	6.83	3.31	1.97	1.13	1.06	0.04
Mn^{54}	2.86	1.73	1.72	0.39	0.97	0.24
Tennessee, Chattanooga						
Precipitation (mm)	[a]—	21	23.8	Dry	173.2	119.40
Sr^{89}	—	1.00	0.37	<0.05	0.45	0.38
Sr^{90}	—	0.58	0.37	0.05	0.78	0.61
Ce^{144}	—	11.4	7.1	1.9	15.0	15.20
Cs^{137}	—	1.0	0.64	0.12	1.61	1.16
Zr^{95}	—	4.60	2.7	4.60	1.32	1.67
Mn^{54}	—	0.63	0.78	<0.28	0.51	0.68
Washington, Seattle						
Precipitation (mm)	50	39.8	23.8	106.4	201.2	120.70
Sr^{89}	1.4	1.5	0.21	1.0	0.2	0.4
Sr^{90}	0.49	0.69	0.93	1.0	1.5	1.1
Ce^{144}	5.4	11.8	12.5	14	16.3	17.1
Cs^{137}	0.52	0.89	1.2	0.81	1.6	1.8
Zr^{95}	2.4	4.8	3.6	3.0	2.2	1.63
Mn^{54}	1.4	2.8	1.4	2.3	2.0	1.16
Wisconsin, Appleton						
Precipitation (mm)	—	50.3	97	15.7	42.9	14.48
Sr^{89}	—	2.8	2.1	0.67	0.54	0.10
Sr^{90}	—	1.5	1.53	0.67	0.94	0.20
Ce^{144}	—	28.8	27.2	12.8	17.2	4.98
Cs^{137}	—	2.2	2.5	1.4	1.70	0.17
Zr^{95}	—	Lost	7.5	2.2	2.2	0.51
Mn^{54}	—	1.9	2.9	1.5	—	0.48

[a] Dash indicates no sample received.

TABLE 4.—ANALYSIS FOR SPECIFIC RADIONUCLIDES IN CANADIAN FALLOUT, JANUARY–MARCH 1964

[Deposition in nc/m²]

Station	January					February					March [a]	
	Sr^{89}	Sr^{90}	Cs^{137}	Zr^{95}	Ba^{140}	Sr^{89}	Sr^{90}	Cs^{137}	Zr^{95}	Ba^{140}	Sr^{90}	Cs^{137}
Calgary	0.00	0.05	0.17	0.10	0.06	0.00	0.17	0.27	0.06	0.12	0.12	0.34
Coral Harbour	0.00	0.15	0.27	[b]—	—	0.00	0.88	1.09	—	—	0.04	0.08
Edmonton	0.00	0.14	0.30	—	—	0.00	0.16	0.38	—	—	0.15	0.47
Ft. Churchill	0.00	0.14	0.15	—	—	0.00	0.07	0.14	—	—	0.08	0.14
Ft. William	0.14	0.49	1.19	—	—	0.00	0.09	0.17	—	—	0.27	0.48
Fredericton	0.20	0.62	0.89	—	—	0.08	0.41	0.74	—	—	1.52	2.51
Goose Bay	0.00	0.25	0.54	—	—	0.11	0.27	0.27	—	—	0.69	1.04
Halifax	0.38	1.12	1.72	0.58	0.03	0.21	1.23	2.14	0.86	0.19	1.18	1.54
Inuvik	0.00	0.17	0.17	—	—	0.06	0.19	0.36	—	—	0.04	0.10
Montreal	0.19	1.25	1.95	1.01	0.09	0.00	0.43	0.74	0.33	0.09	0.84	1.35
Moosonee	0.17	0.44	0.80	—	—	0.05	0.26	0.37	—	—	0.32	0.62
Ottawa	0.16	0.45	0.85	—	—	0.00	0.19	0.28	—	—	0.49	0.96
Quebec	0.41	1.01	2.09	—	—	0.18	0.61	1.20	—	—	0.48	2.02
Regina	0.00	0.11	0.10	—	—	0.00	0.11	0.30	—	—	0.16	0.27
Resolute	0.25	0.86	1.20	—	—	0.09	0.59	0.79	—	—	0.26	0.40
St. John's, Nfld.	—	—	—	—	—	0.05	1.57	2.00	—	—	1.31	2.24
Saskatoon	0.00	0.12	0.18	—	—	0.00	0.14	0.25	—	—	0.09	0.13
Saulte Ste. Marie	0.00	0.76	1.30	—	—	0.07	0.29	0.55	—	—	1.06	1.81
Toronto	0.00	0.26	0.90	—	—	0.09	0.20	0.54	—	—	1.30	2.00
Vancouver	0.67	1.84	3.32	1.88	0.03	0.18	0.93	1.75	0.36	0.08	1.89	2.80
Whitehorse	0.00	0.00	0.13	—	—	0.00	0.09	0.18	—	—	0.04	0.24
Windsor	0.28	0.65	1.24	—	—	0.06	0.39	0.66	—	—	1.73	0.52
Winnipeg	0.00	0.12	0.17	0.13	0.04	0.00	0.08	0.17	0.10	0.11	0.20	0.36
Yellowknife	0.00	0.11	0.16	—	—	0.00	0.12	0.16	—	—	0.17	0.22

[a] Sr^{89}, Zr^{95} and Ba^{140} were not recorded for March because of insignificantly low levels. [b] Dash indicates no analysis.

Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, April 1964

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after collection; publication in *RHD* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Analytical Errors

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectroscopy.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically for strontium–89 and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation is dependent upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclide and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The ± 2 standard deviations (2σ) about the measured concentration correspond to a 95 percent certainty that the true concentration is within this range. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10%
Barium-140	0 to 100	±10	100 or greater	±10%
Cesium-137	0 to 100	±10	100 or greater	±10%
Strontium-89	0 to 50	±5	50 or greater	±10%
Strontium-90	0 to 20	±2	20 or greater	±10%

[a] Two standard deviations (2σ).

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

[2] The conversion factor is 1.18×10^{-3} g K/pc K^{40}.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations[2] determined from the gamma spectrum.

Data Presentation

Table 2 presents summaries of the analyses for April 1964 (March 29–April 25, 1964). Although not shown in table 2, the iodine–131 and barium–140 monthly average concentrations in milk were less than 10 pc/liter. Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine–131 and barium–140 in October 1963, when nondetectable concentrations of these radionuclides were considered to be zero.

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modification to the isograms are made according to available information on milksheds.

In order to develop the distribution of the network's stations versus radionuclide concentrations in milk, table 3 has been prepared using monthly averages shown in table 2.

Continuing the practice followed in previous issues of *RHD*, the average monthly strontium–90 concentrations in pasteurized milk from 16 selected cities in the sampling program are presented in figure 3. Each graph shows the strontium–90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year. The last column in table 2 shows the most recent issue in which a graph of the strontium–90 concentration was given for each station. A tabulation of the network monthly maximum, minimum, and average radionuclide concentration in milk was given for March 1960–March 1964 in the July 1964 issue of *RHD*.

TABLE 2.—STABLE ELEMENT AND RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, APRIL 1964 [a]

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Potassium (g/liter)		Strontium-89		Strontium-90		Cesium-137		Last Sr^{90} graph in *RHD* (1964)
		First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	
Ala:	Montgomery	1.19	1.15	1.5	1.4	<5	<5	24	26	100	95	June
Alaska:	Palmer	1.16	1.25	1.5	1.5	10	10	23	20	160	155	July
Ariz:	Phoenix	1.18	1.17	1.5	1.4	<5	<5	4	8	25	35	May
Ark:	Little Rock	1.18	1.15	1.5	1.5	<5	5	43	56	165	170	July
Calif:	Sacramento	1.25	1.23	1.6	1.5	<5	<5	11	12	65	60	August
	San Francisco	1.23	1.22	1.5	1.4	<5	5	13	16	75	65	June
Canal Zone:	Cristobal	1.13	1.08	1.6	1.5	<5	<5	6	6	50	55	July
Colo:	Denver	1.23	1.28	1.6	1.6	<5	5	19	21	90	95	August
Conn:	Hartford	1.15	1.11	1.6	1.4	<5	<5	23	22	185	175	August
Del:	Wilmington	1.21	1.21	1.6	1.5	<5	<5	21	28	150	155	May
D. C:	Washington	1.17	1.12	1.6	1.6	<5	<5	18	21	105	110	June
Fla:	Tampa	1.21	1.12	1.5	1.5	<5	<5	15	17	200	240	May
Ga:	Atlanta	1.21	1.17	1.6	1.5	<5	<5	35	37	160	180	June
Hawaii:	Honolulu	1.18	1.13	1.6	1.6	<5	<5	11	12	80	80	July
Idaho:	Idaho Falls	1.19	1.18	1.6	1.3	5	10	27	40	220	230	May
Ill:	Chicago	1.18	1.22	1.6	1.6	<5	<5	21	18	145	145	June
Ind:	Indianapolis	1.22	1.22	1.6	1.5	<5	<5	22	20	120	120	August
Iowa:	Des Moines	1.22	1.26	1.5	1.4	<5	10	27	27	110	110	May
Kans:	Wichita	1.21	1.19	1.5	1.4	10	5	23	18	80	80	July
Ky:	Louisville	1.18	1.16	1.6	1.5	<5	<5	32	37	125	125	May
La:	New Orleans	1.22	1.18	1.5	1.5	<5	<5	54	66	165	205	July
Maine:	Portland	1.20	1.18	1.6	1.6	<5	<5	31	30	220	205	May
Md:	Baltimore	1.17	1.13	1.5	1.6	<5	<5	20	22	115	135	May
Mass:	Boston	1.20	1.20	1.6	1.6	<5	<5	32	32	265	255	June
Mich:	Detroit	1.19	1.20	1.6	1.5	<5	<5	19	19	135	130	August
	Grand Rapids	1.21	1.23	1.5	1.5	<5	<5	22	19	145	140	May
Minn:	Minneapolis	1.18	1.24	1.6	1.5	10	10	35	30	190	160	June
Miss:	Jackson	1.26	1.22	1.5	1.4	5	<5	41	60	125	140	August
Mo:	Kansas City	1.22	1.19	1.5	1.4	5	10	28	30	100	110	August
	St. Louis	1.20	1.23	1.5	1.4	5	10	23	26	100	100	July
Mont:	Helena	1.22	1.19	1.5	1.4	10	15	31	29	235	225	July
Nebr:	Omaha	1.21	1.14	1.5	1.4	5	5	25	28	105	120	May
Nev:	Las Vegas	1.24	1.18	1.6	1.5	<5	<5	15	6	95	90	June
N. H:	Manchester	1.22	1.20	1.7	1.6	<5	<5	32	30	260	265	May
N. J:	Trenton	1.19	1.18	1.6	1.6	5	<5	18	18	140	140	August
N. Mex:	Albuquerque	1.19	1.23	1.5	1.4	<5	10	12	17	60	90	July
N. Y:	Buffalo	1.16	1.16	1.6	1.6	<5	<5	20	22	170	170	August
	New York	1.16	1.16	1.6	1.5	<5	<5	25	25	190	195	June
	Syracuse	1.18	1.14	1.6	1.6	<5	<5	22	21	170	165	July
N. C:	Charlotte	1.22	1.15	1.5	1.4	<5	<5	31	37	115	125	July
N. Dak:	Minot	1.21	1.22	1.5	1.5	15	10	58	62	160	165	May
Ohio:	Cincinnati	1.21	1.18	1.6	1.5	<5	<5	24	27	125	120	August
	Cleveland	1.21	1.18	1.6	1.5	<5	<5	22	19	135	140	July
Okla:	Oklahoma City	1.18	1.13	1.6	1.6	<5	<5	25	27	90	80	June
Ore:	Portland	1.24	1.26	1.5	1.5	5	10	27	36	155	185	August
Pa:	Philadelphia	1.21	1.19	1.6	1.5	<5	<5	20	22	145	150	July
	Pittsburgh	1.19	1.16	1.6	1.5	<5	<5	28	28	170	180	July
P. R:	San Juan	1.16	1.10	1.6	1.6	<5	<5	12	16	70	100	July
R. I:	Providence	1.18	1.16	1.6	1.6	<5	<5	25	24	185	180	May
S. C:	Charleston	1.18	1.17	1.5	1.5	<5	<5	34	35	135	140	August
S. Dak:	Rapid City	1.19	1.01	1.5	1.5	10	5	38	35	175	145	June
Tenn:	Chattanooga	1.23	1.18	1.5	1.4	5	<5	38	54	145	165	June
	Memphis	1.21	1.16	1.5	1.5	<5	<5	32	42	90	85	May
Tex:	Austin	1.17	1.09	1.6	1.6	<5	<5	10	9	45	40	June
	Dallas	1.19	1.12	1.6	1.5	<5	<5	22	22	85	70	August
Utah:	Salt Lake City	1.21	1.25	1.5	1.4	5	5	27	32	215	225	July
Vt:	Burlington	1.18	1.20	1.6	1.5	<5	<5	26	25	210	210	August
Va:	Norfolk	1.18	1.13	1.6	1.6	<5	<5	20	24	105	105	August
Wash:	Seattle	1.21	1.22	1.5	1.5	10	10	21	24	120	140	June
	Spokane	1.24	1.30	1.6	1.4	5	10	33	27	145	165	August
W. Va:	Charleston	1.18	1.11	1.5	1.5	<5	<5	26	28	110	105	June
Wis:	Milwaukee	1.22	1.24	1.7	1.6	<5	<5	19	21	160	160	May
Wyo:	Laramie	1.18	1.25	1.5	1.4	10	20	21	22	115	115	May
Network average		1.20	1.18	1.6	1.5	<5	<5	24.8	26.8	136	140	Nov. 63

[a] The monthly average iodine-131 and barium-140 concentration at each station was <10 pc/liter.

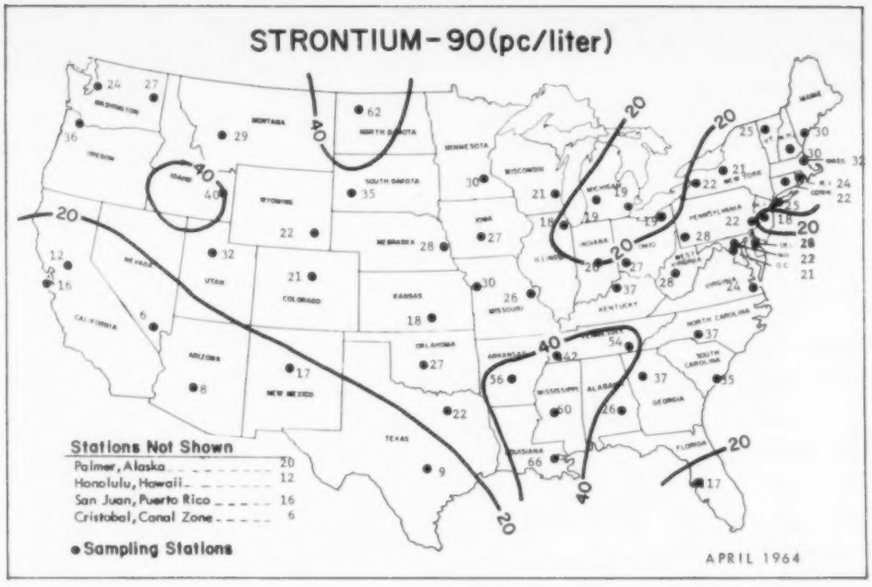

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, APRIL 1964

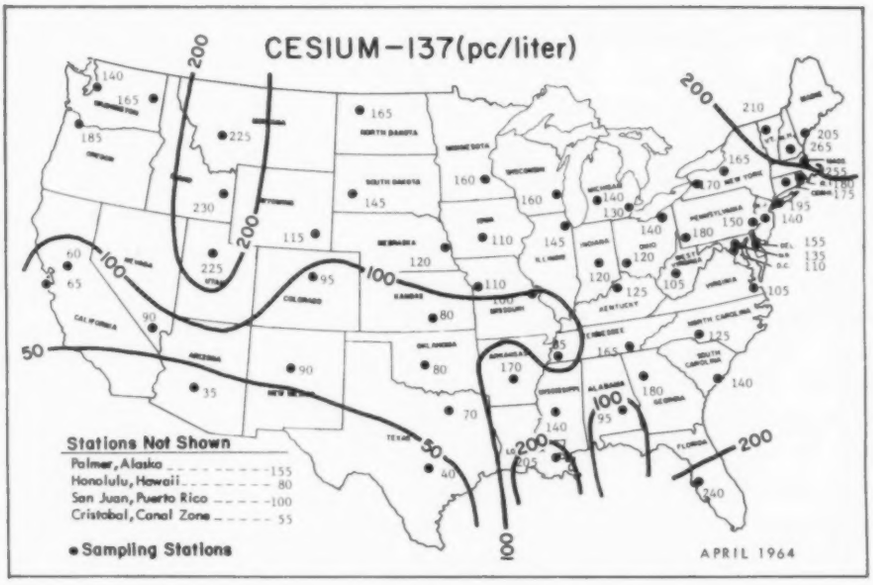

FIGURE 2.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, APRIL 1964

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, APRIL 1964

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
(pc/liter)	Number of stations	(pc/liter)	Number of stations	(pc/liter)	Number of stations	(pc/liter)	Number of stations	(pc/liter)	Number of stations
<5	43	<1-9	4	<10	63	<5-45	2	<10	63
5	7	10-14	2			50-95	12		
10	11	15-19	10			100-145	23		
15	1	20-24	15			150-195	17		
20	1	25-29	13			200-245	7		
		30-34	6			250-295	2		
		35-39	6						
		40-69	7						

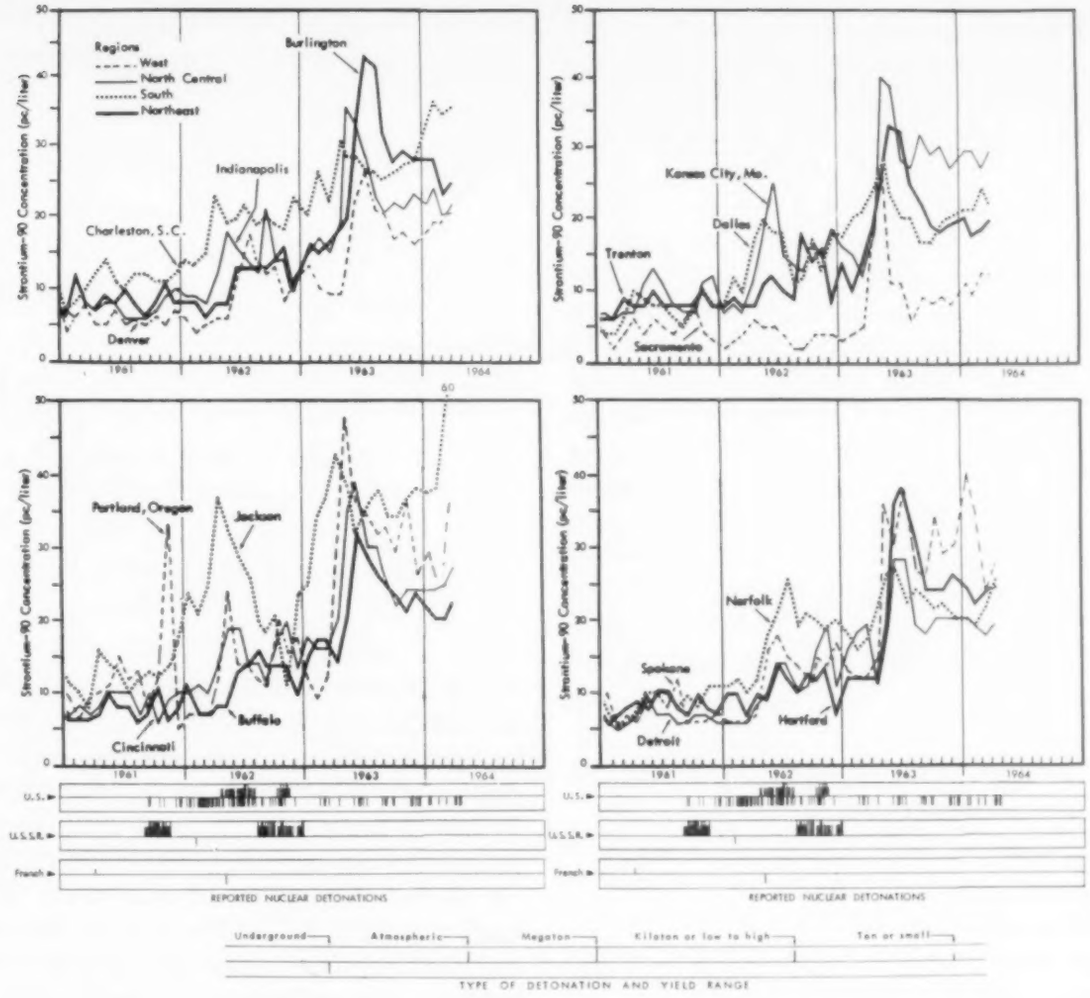

FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961–APRIL 1964

2. Indiana Milk Network April 1964

Bureau of Environmental Sanitation, Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (figure 4).

The milk samples are routinely analyzed for iodine–131, cesium–137, barium–140, strontium–89 and strontium–90. Until August 1963, analyses for the gamma emitters iodine–131, cesium–137 and barium–140 were conducted on a weekly basis, except when iodine–131 exceeded 100 pc/liter, at which times the frequency of sampling was increased. Because of continued low concentrations of the short-lived gamma emitters, the sampling frequency was reduced in August 1963 to once per month for the northeast, southeast and southwest milksheds. Strontium–89 and strontium–90 analyses are performed monthly for each station.

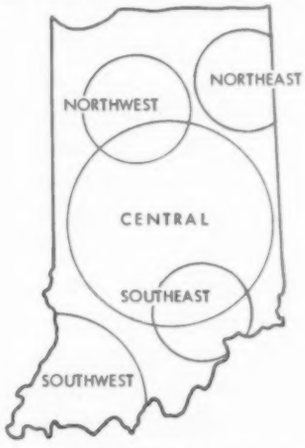

FIGURE 4.—INDIANA MILK SAMPLING LOCATIONS

An ion exchange analytical procedure (*3*) is employed for strontium–89 and strontium–90 analyses. Minimum detectable levels for strontium–89 and strontium–90 are about 5 and 1 pc/liter, respectively. A 512–channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine–131, cesium–137, and barium–140. Analyses of counting statistics indicate that the lower limit of detectability for both iodine–131 and barium–140 is 5 pc/liter. Cesium–137 analyses are subject to a 6 percent error at the 100 pc/liter level. Additional factors such as drift of the analyzer and calibration factors will increase these limits to some extent.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 4. The State average is an arithmetic average of the station values.

TABLE 4.—RADIONUCLIDES IN INDIANA MILK, APRIL 1964 [a]

[Radionuclide concentrations in pc/liter]

Sampling location	Calcium (g/liter)	K^{40}	Sr^{90}	Cs^{137}
Northeast	1.14	1,420	17	115
Southeast	1.14	1,470	18	110
Central	1.14	1,410	18	115
Southwest	1.10	1,600	17	90
Northwest	1.14	1,400	17	130
Average	1.13	1,460	17	110

[a] The monthly average iodine-131, strontium-89, and barium-140 concentrations at each station were zero.

3. New York Milk Network February 1964

Division of Environmental Health Services, State of New York Department of Health

Milk samples collected routinely from six cities—Albany, Buffalo, Massena, Newburg, New York City, and Syracuse (figure 5) are analyzed for their radionuclide content by the State of New York Department of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium–89, strontium–90, iodine–131, cesium–137 and barium–lanthanum–140 at all stations except Massena, where samples are composited bi-weekly, and at New York City

FIGURE 5.—NEW YORK MILK SAMPLING LOCATIONS

where one daily milk sample representing the total milk supply for that day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed daily for iodine–131. In the event that any city reports iodine–131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

A matrix method (*4*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

The analytical procedure for strontium–89 and strontium–90 is based on ion exchange methods. Cations (including radiostrontium) are eluted from the ion exchange resin with sodium chloride solution, strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylenediaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm^2 window. The strontium–90 portion is differentially estimated by a second count 40 hours later to determine the rate of in-growth of its daughter product yttrium–90. The monthly average radionuclide concentrations in milk are shown in table 5.

TABLE 5.—RADIONUCLIDES IN NEW YORK MILK, FEBRUARY 1964 [a]

[Average concentrations in pc/liter]

Sampling location	Strontium-89	Strontium-90	Cesium-137
Albany	4	17	124
Buffalo	4	10	92
Massena	6	32	208
Newburgh	6	16	135
New York City	5	21	131
Syracuse	<3	21	121
Average	5	20	135

Note: Ba-La^{140} refers to the sum of these two nuclides in equilibrium.
[a] The monthly average I^{131} and Ba-La^{140} at each station was <20 pc/liter.

4. Canadian Milk Network[3] April 1964

Radiation Protection Division
Department of National Health and Welfare, Ottawa, Canada

The Radiation Protective Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 6) in the same areas as the air and precipitation stations. At present, the analyses include determination of iodine–131, strontium–89, cesium–137 and strontium–90 as well as stable potassium and calcium.

[3] Data from Radiation Protection Programs, Vol. 2, No. 5: 25–29, Radiation Protection Division, Canadian Department of National Health and Welfare (May 1964).

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies and are combined into weekly composites and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine–131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–90, strontium–89, cesium–137, and stable potassium and calcium.

Analytical Methods

Radiochemical methods are used for the analysis of iodine–131 (*5*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450°C, dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low background beta counter. Strontium–90 is determined separately by extracting and counting the yttrium–90 daughter nuclide while strontium–89 is

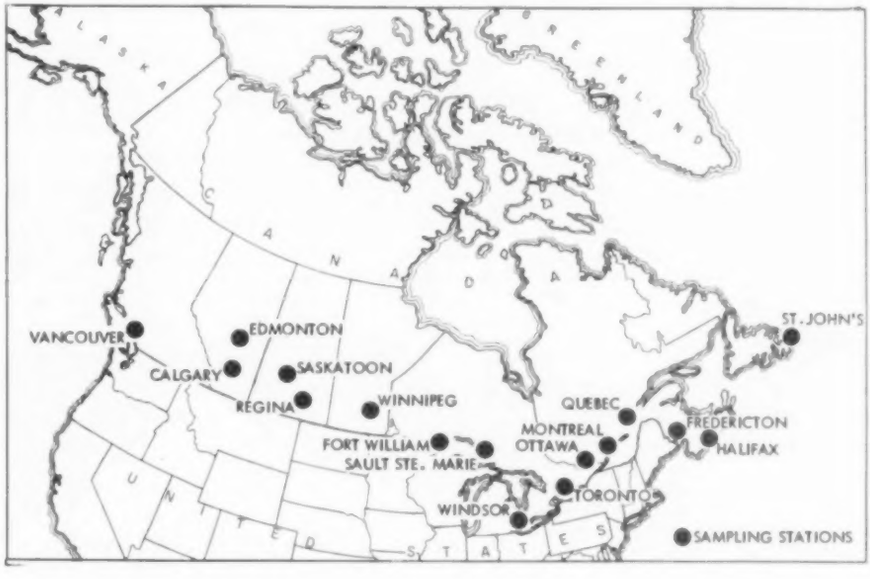

FIGURE 6.—CANADIAN MILK SAMPLING STATIONS

estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium–137 is determined by gamma spectroscopy using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with standard preparations. The stable potassium content is estimated from the potassium–40 concentration.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium–137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 6.

TABLE 6.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK [a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±25%	±10%

[a] All errors are 2σ values, representing 95 percent confidence.

Results

Table 7 presents monthly averages of strontium–90, cesium–137 and stable calcium and potassium in Canadian whole milk. Spot checks for iodine–131 and strontium–89 indicate that all samples had <5 pc/liter.

TABLE 7.—RADIONUCLIDES IN CANADIAN WHOLE MILK, APRIL 1964

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90	Cesium-137
Calgary	1.34	1.5	46.2	286
Edmonton	1.41	1.5	35.1	222
Ft. William	1.33	1.6	57.8	310
Fredericton	1.46	1.7	49.9	349
Halifax	1.41	1.6	37.7	270
Montreal	1.40	1.7	37.2	277
Ottawa	1.35	1.7	32.9	227
Quebec	1.34	1.6	49.3	322
Regina	1.31	1.6	52.1	212
St. John's, Nfld.	1.40	1.6	44.1	266
Saskatoon	1.34	1.6	59.6	229
Sault Ste. Marie	1.33	1.6	37.9	202
Toronto	1.40	1.6	18.9	137
Vancouver	1.46	1.5	42.7	271
Windsor	1.44	1.6	17.0	114
Winnipeg	1.31	1.6	44.9	234
Average	1.38	1.6	41.5	246

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MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, MAY 1963—APRIL 1964

Division of Radiological Health, Public Health Service

Radionuclide concentration values reported by the Pasteurized Milk Network (*1*) can be used to estimate the contribution of milk to a population's radiation exposure. This is done by determining both the annual average concentrations of specific radionuclides in milk and the average daily milk consumption of a representative individual in a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average concentrations of strontium–89, strontium–90, and cesium–137 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U. S. population (*2,3*).

To arrive at a basis of comparison between the daily rates of intake of the radionuclides from the milk component of the diet and the Federal Radiation Council's ranges of transient daily rates of intake (*4*), it is assumed that the average daily milk consumption of an individual in a population group is one liter. The Guides, however, apply to total intake from all sources. The upper limits of Range II correspond to the Radiation Protection Guide (RPG) for iodine–131 and to one-third of the Radiation Protection Guide for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*). The FRC emphasizes that the annual acceptable risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*).

Annual averages of radionuclide concentrations in milk sampled by the PHS Pasteurized Milk Network are presented in table 1. The data in table 1 are calculated as follows: Results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[1] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk (*3,4*).

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as weather conditions and dairying practices. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

[1] Beginning with the October 1963 data, iodine–131 values of <10 pc/liter are considered to be zero for averaging purposes; previously, 5 pc/liter was used for calculating the averages.

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TABLE 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK[a]

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Cesium-137	
		April 1963—March 1964	May 1963—April 1964	April 1963—March 1964	May 1963—April 1964	April 1963—March 1964	May 1963—April 1964
Ala:	Montgomery	38	31	22	23	89	91
Alaska:	Palmer	28	27	24	24	140	149
Ariz:	Phoenix	8	6	4	4	22	24
Ark:	Little Rock	80	64	44	45	166	168
Calif:	Sacramento	32	21	11	11	66	65
	San Francisco	50	31	14	13	79	75
Colo:	Denver	23	22	18	19	90	93
Conn:	Hartford	21	21	26	26	173	182
Del:	Wilmington	27	25	26	27	141	148
D. C:	Washington	37	33	20	20	105	106
Fla:	Tampa	18	15	15	15	231	235
Ga:	Atlanta	58	49	32	33	156	161
Hawaii:	Honolulu	0	16	11	11	79	82
Idaho:	Idaho Falls	48	47	27	30	167	178
Ill:	Chicago	18	18	21	21	120	125
Ind:	Indianapolis	26	24	24	24	108	112
Iowa:	Des Moines	54	51	28	28	98	102
Kans:	Wichita	37	35	22	22	78	80
Ky:	Louisville	76	65	35	35	121	125
La:	New Orleans	68	51	46	47	158	162
Maine:	Portland	26	26	33	34	220	228
Md:	Baltimore	45	42	22	23	129	133
Mass:	Boston	31	31	36	37	248	261
Mich:	Detroit	16	15	20	21	119	124
	Grand Rapids	17	16	21	22	127	132
Minn:	Minneapolis	47	47	33	34	161	166
Miss:	Jackson	69	53	37	39	119	121
Mo:	Kansas City	60	56	30	31	91	96
	St. Louis	43	41	24	25	93	96
Mont:	Helena	43	43	30	31	195	207
Nebr:	Omaha	45	44	27	28	103	107
Nev:	Las Vegas	15	14	11	11	77	81
N. H:	Manchester	29	28	35	36	268	280
N. J:	Trenton	21	21	22	22	132	138
N. Mex:	Albuquerque	17	16	11	12	49	54
N. Y:	Buffalo	21	21	23	24	149	156
	New York	29	29	31	31	178	188
	Syracuse	24	24	25	25	148	156
N. C:	Charlotte	58	50	33	34	128	131
N. Dak:	Minot	81	80	55	58	150	157
Ohio:	Cincinnati	32	27	27	28	101	105
	Cleveland	23	22	23	23	117	123
Okla:	Oklahoma City	48	41	24	24	93	93
Ore:	Portland	60	50	32	33	171	177
Pa:	Philadelphia	25	24	24	24	134	140
	Pittsburgh	32	31	30	31	160	168
P. R:	San Juan	36	25	14	13	89	88
R. I:	Providence	25	23	29	29	178	186
S. C:	Charleston	38	32	29	29	133	136
S. Dak:	Rapid City	61	59	42	43	164	170
Tenn:	Chattanooga	82	68	40	42	154	158
	Memphis	62	51	33	33	93	95
Tex:	Austin	19	14	10	9	49	48
	Dallas	42	32	21	21	84	84
Utah:	Salt Lake City	31	30	26	27	174	186
Vt:	Burlington	25	25	29	30	193	203
Va:	Norfolk	37	31	22	23	108	109
Wash:	Seattle	50	45	27	27	157	161
	Spokane	47	45	30	31	147	154
W. Va:	Charleston	61	55	31	31	108	110
Wis:	Milwaukee	17	16	20	21	129	136
Wyo:	Laramie	35	35	23	24	119	120
Network average		39	34	26.0	26.6	131	136

[a] Annual averages were computed on basis of 52 weekly averages.

QUALITY CONTROL CROSS-CHECK ANALYSES OF GAMMA EMITTERS IN MILK, DIVISION OF RADIOLOGICAL HEALTH, APRIL—OCTOBER, 1963

Marvin Rosenstein, Kenneth H. Falter, and Abraham S. Goldin[1]

In the initial report (*1*) of the Analytical Quality Control Service (AQCS), the objectives and operations of the overall program, along with the fundamental means of meeting these objectives, were reviewed. Included also were the data from the first two technical experiments[2] on the determination of iodine–131 in milk showing that individual analyses can be performed with an accuracy of ±10 percent. Among the other activities of AQCS described in that report was the distribution of natural environmental samples for cross-check purposes. Such a program has been in operation in one form or another for fluid milk for several years. In this report, data on the analysis of gamma emitters covering the period April 1963 through October 1963 are presented and discussed.

Distribution and Analysis of Samples

Analyses of milk for radionuclides and stable elements are performed routinely in three Division of Radiological Health laboratories, located in Las Vegas, Nevada; Montgomery, Alabama; and Winchester, Massachusetts. In addition to these laboratories, which carry the bulk of the Pasteurized Milk Network analytical load, the Division's laboratory at Honolulu and the Milk and Food Laboratory (Division of Environmental Engineering and Food Protection) at Cincinnati, Ohio, were included in this study. The primary purpose of the program is to check the agreement among these several laboratories.

During the period April through October 1963 each participating laboratory analyzed two cross-check samples in triplicate each month. The concentrations of I^{131}, Ba^{140}, Cs^{137}, and potassium in each sample were measured at each laboratory by gamma scintillation spectroscopy.[3] Values were reported to the nearest picocurie per liter or for potassium to the nearest 0.01 gram per liter. The program thus provided a measure of the degree to which the laboratories results agreed with each other.

Data obtained through the internal quality control programs at each laboratory, while not discussed in this report, have demonstrated acceptable internal precision, which is a necessary condition before the cross-check intercomparisons can be made. The monthly cross-checks thus complement intralaboratory quality control and the analysis of samples of known concentration. This cross-check program has made possible the continuous quality control monitoring of all gamma spectroscopic analyses of milk samples and has provided a greater volume of data on actual environmental samples than could be obtained through a series of technical experiments. Corrective action taken as a result of the information obtained from technical experiments is also reflected in improvement and maintenance of laboratory agreement in the cross-check program.

Procedure

Tables 1–4 give the date of the sample, the mean of triplicate analyses from each laboratory, the observed range between the largest and smallest values of the laboratory means, and the allowable range calculated as analytically acceptable and attainable for I^{131}, Ba^{140}, Cs^{137}, and potassium. The observed laboratory range is utilized to determine the agreement among laboratories. This agreement is measured by comparison of the range between laboratory values with predetermined acceptable

[1] Mr. Rosenstein is Program Coordinator and Dr. Goldin is Director of the Analytical Quality Control Service of the Division of Radiological Health, located at the Northeastern Radiological Health Laboratory, Winchester, Massachusetts. Mr. Falter is Assistant Chief, Biometrics Unit, Research Branch, Division of Radiological Health, Public Health Service, U.S. Department of Health, Education and Welfare, Washington 25, D. C.

[2] A technical experiment, as defined by AQCS, is the analysis and interpretation of data obtained from the determination, by participating laboratories, of a single nuclide present in a known concentration in a suitable matrix.

[3] The determination of Ba^{140} at one laboratory is done by radiochemistry and the determination of potassium at another laboratory is done by flame photometry.

ranges. Statistically, the range is almost as efficient a measurement of dispersion as the standard deviation when the range is calculated from a set of data in which the number of results in the set are small (*2*).

The allowable ranges are calculated from assigned standard deviations using factors from statistical tables (*3*). These ranges depend on the concentration of the nuclide or element under consideration, the number of replicates, and the number of laboratories returning results. They specify a value which 97.5 percent of all observed concentrations ranges should not exceed when analytical specifications are being met.

The allowable ranges are calculated as follows:

1. Standard deviation values for individual determinations are selected on the basis of the capabilities of the analytical measurements and on the requirements for agreement in the determinations. For the radionuclides I^{131}, Ba^{140}, and Cs^{137} the standard deviation for levels ≤ 100 pc/liter is $\pm$ 5 pc/liter, and for levels >100 pc/liter it is $\pm$ 5 percent.
   The standard deviation for stable potassium is $\pm$ 0.06 gm/liter for all levels in milk.

2. The standard deviation for means (σ_m), for each radionuclide or element is calculated by dividing the assigned standdard deviation for individual values (σ) by the square root of the number of replicate determinations, in this case three:

$$\sigma_m = \frac{\sigma}{\sqrt{3}}$$

   The values for σ_m are:
   I^{131}, Ba^{140}, Cs^{137}
   $\pm$ 2.9 pc/liter for levels ≤ 100 pc/liter;
   $\pm$ 2.9 percent for levels >100 pc/liter
   K $\pm$ 0.035 gm/liter for all levels

3. Using the above standard deviations for means (σ_m), the allowable range for each nuclide or element is calculated from the following relationship:

$$\text{Allowable Range} = D\ \sigma_m$$

   where D = factor, determined from statistical tables (*3*), as a function of the number of laboratory means and the statistical confidence level chosen. The number of laboratory means in this study was from three to five, depending on the number of laboratories returning results. A confidence limit equivalent to a "two-sigma" level was used in all cases.

4. A chart can subsequently be prepared showing the allowable range of the laboratory means. This range defines a level which 97.5 percent of observed ranges *should not exceed*, since the upper "two-sigma" limit excludes 2.5 percent of the distribution. In the chart the allowable range is shown as a function of the level being measured and the number of laboratories involved. A sample of such a chart for I^{131}, Ba^{140}, and Cs^{137} is shown in figure 1.

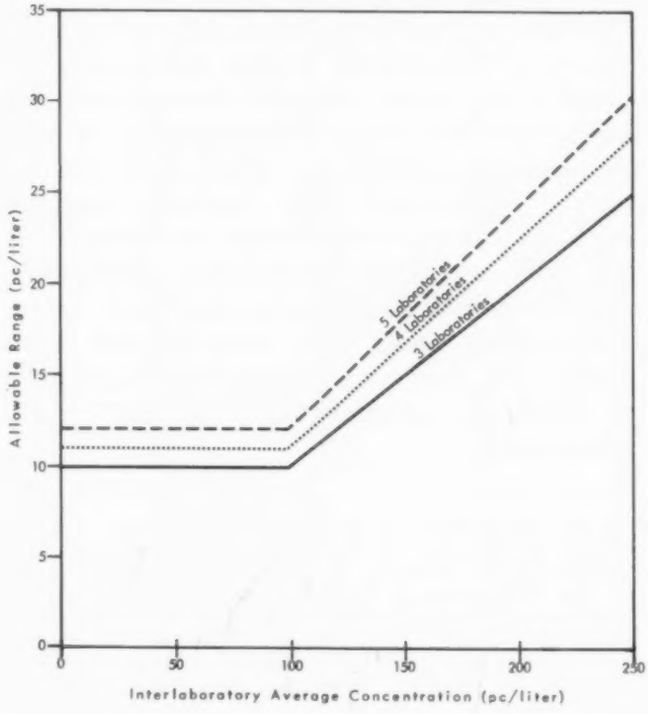

FIGURE 1.—ACCEPTABLE RANGE OF LABORATORY MEANS AT THE 2σ CONFIDENCE LEVEL VERSUS AVERAGE I^{131}, Ba^{140}, OR Cs^{137} CONCENTRATIONS IN MILK SAMPLES

In the final analysis, observed ranges that are greater than the allowable range indicate that the laboratories do not agree with each other within the standard deviation (σ) chosen as acceptable. When the agreement is not acceptable, it may be because the result from one laboratory was erratic or because the overall spread of the results was excessive, without being attributable to any one laboratory.

Discussion of Results

In the following discussion, it should be remembered that the data presented here are restricted to the period April–October 1963, and to the levels present in the samples. The conclusions presented here should not be extrapolated to other periods, other laboratories, or other levels.

Iodine–131: The data in table 1 indicate that there was good agreement among the laboratories for I^{131} analyses by gamma spectroscopy. In every case during the April–October 1963 period the levels of I^{131} in the milk samples distributed were very low, approaching 0 pc/liter. In each of the three cases where the agreement was not acceptable (samples 3, 11 and 12) a single laboratory (not the same one each time) reported results higher than the others. The results, while of interest analytically, were not large deviations. Therefore, the I^{131} results, in general, substantiate the findings of the first AQCS report (*1*), that I^{131} analyses were performed with an acceptable degree of analytical control.

Barium–140: The data in table 2 indicate that there was good agreement among the laboratories for Ba^{140} analyses. Barium–140 is determined in four of the five laboratories by gamma spectroscopy and in the fifth laboratory (laboratory B) by a radiochemical procedure. Again, in all cases during the April–October 1963 period, the levels of Ba^{140} in the milk samples distributed were very low, approaching 0 pc/liter. In three samples (samples 12, 13 and 14) laboratory B appeared to

TABLE 1.—MEAN IODINE-131 CONCENTRATIONS IN MILK CROSS-CHECK SAMPLES

[Concentrations in pc/liter]

Sample identification and date (1963)	Laboratory					Observed range	Allowable range
	A	B	C	D	E		
October							
#1	2.6	6.7	8.0	0.0	3.7	8.0	11.7
#2	9.5	5.3	5.7	0.0	4.0	9.5	11.7
September							
#3	4.7	1.0	13.7	0.0	2.3	[a] 13.7	11.7
#4	2.3	6.3	10.3	0.0	1.0	10.3	11.7
August							
#5	0.0	2.7	[b]—	0.0	8.7	8.7	10.9
#6	2.0	10.3	0.0	0.0	1.3	10.3	11.7
July							
#7	0.3	7.7	9.0	0.0	4.3	9.0	11.7
#8	0.0	2.3	2.3	0.0	6.0	6.0	11.7
June							
#9	1.0	6.3	1.7	1.3	0.0	6.3	11.7
#10	—	4.7	6.0	0.0	3.7	6.0	10.9
May							
#11	4.7	7.3	6.0	0.0	12.3	[a] 12.3	11.7
#12	2.0	14.3	5.7	0.0	3.0	[a] 14.3	11.7
April							
#13	6.3	7.3	6.0	4.7	6.0	2.6	11.7
#14	3.3	10.3	1.3	1.0	10.3	9.3	11.7

[a] Observed range is greater than allowable range.
[b] Dash indicates no analysis performed.

be obtaining higher results than the other laboratories. However, the remaining data indicate that this discrepancy had been corrected as the result of a modification of the radiochemical procedure. These results, therefore, demonstrate that Ba^{140} analyses were performed with an acceptable degree of analytical control. They also incidentally demonstrate that satisfactory agreement was obtained although radically different analytical techniques were employed.

TABLE 2.—MEAN BARIUM-140 CONCENTRATIONS IN MILK CROSS-CHECK SAMPLES

[Concentrations in pc/liter]

Sample identification and date (1963)	Laboratory					Observed range	Allowable range
	A	B	C	D	E		
October							
#1	0.0	3.3	8.7	0.0	0.0	8.7	11.7
#2	0.0	3.7	2.3	0.0	[a] —	3.7	10.9
September							
#3	0.0	3.7	8.7	0.0	0.0	8.7	11.7
#4	4.7	3.7	3.7	0.0	0.0	4.7	11.7
August							
#5	0.7	5.0	—	0.0	0.0	5.0	10.9
#6	5.3	5.3	0.0	2.7	0.0	5.3	11.7
July							
#7	0.0	3.7	10.0	0.0	0.3	10.0	11.7
#8	1.3	3.3	5.7	2.3	0.0	5.7	11.7
June							
#9	2.7	8.7	7.3	0.0	0.0	8.7	11.7
#10	—	7.7	4.7	0.0	0.0	7.7	10.9
May							
#11	0.0	8.0	6.0	0.0	5.0	8.0	11.7
#12	2.3	16.7	4.7	0.0	5.0	[b] 16.7	11.7
April							
#13	3.3	14.0	6.7	0.0	10.0	[b] 14.0	11.7
#14	0.7	16.0	3.0	0.0	0.0	[b] 16.0	11.7

[a] Dash indicates no analysis performed.
[b] Observed range greater than the allowable range.

Cesium–137: The application of cross-check analyses to uncover disagreement among laboratories is illustrated nicely for the Cs^{137} analyses in milk during the April–October 1963 period. The data (table 3) from the ten samples from April–August 1963 show that whenever the Cs^{137} level was greater than 70 to 75 pc/liter (seven of the ten cases), the observed range was greater than the allowable range and in some cases extremely large (6 and 10). In all seven of these cases, either laboratory A, B, or both yielded results higher than the other laboratories. During June, 1963, a milk sample, containing a known amount of Cs^{137}, was distributed to all five participating laboratories to determine which laboratories were yielding accurate data and which laboratories were yielding biased data. As a result of that study, completed in September 1963, laboratories A and B recalibrated their gamma spectrometers with a standardized Cs^{137} solution. The data in table 3 for September–October 1963 indicate the resulting improvement. The observed range for sample number 3, while slightly larger than expected, is not particularly high. Data obtained since October 1963 (not included in table 3) further substantiate this improvement.

TABLE 3.—MEAN CESIUM-137 CONCENTRATIONS IN MILK CROSS-CHECK SAMPLES

[Concentrations in pc/liter]

Sample identification and date (1963)	Laboratory					Observed range	Allowable range
	A	B	C	D	E		
October							
#1	76.4	68.7	72.3	72.3	68.3	8.1	11.7
#2	51.0	46.3	51.0	49.0	43.7	7.3	11.7
September							
#3	94.7	82.3	89.3	92.3	86.7	[a] 12.4	11.7
#4	257.0	255.3	239.3	250.0	248.3	17.7	27.8
August							
#5	140.0	121.0	[b] —	132.0	124.0	[a] 19.0	14.3
#6	271.0	220.0	209.0	234.7	220.3	[a] 62.0	26.6
July							
#7	272.3	278.3	247.3	250.7	256.3	[a] 31.0	30.0
#8	125.3	146.0	132.0	132.7	131.0	[a] 20.7	15.6
June							
#9	58.3	63.0	60.3	65.3	63.3	7.0	11.7
#10	—	121.0	99.0	110.0	110.7	[a] 22.0	12.0
May							
#11	71.0	66.3	61.0	63.0	62.0	10.0	11.7
#12	85.3	90.3	78.3	76.3	76.7	[a] 14.0	11.7
April							
#13	37.7	39.3	32.3	35.3	31.0	8.3	11.7
#14	81.7	91.7	75.0	75.7	78.3	[a] 16.7	11.7

[a] Observed range greater than allowable range.
[b] Dash indicates no analysis performed.

Potassium: Potassium is determined in four of the five laboratories by gamma spectroscopy and in the fifth by flame photometry. The potassium content in milk is fairly constant, usually between 1.40 and 1.60 gm/liter. The data given in table 4 indicate potassium analyses were not performed with the desired degree of analytical control; in every case during the April–October 1963 period the observed range was larger than the allowable range. While potassium analyses are

TABLE 4.—MEAN POTASSIUM CONCENTRATIONS IN MILK CROSS-CHECK SAMPLES

[Concentrations in g/liter]

Sample identification and date (1963)	Laboratory					Observed range	Allowable range
	A	B	C	D	E		
October							
#1	1.61	1.43	1.64	1.43	1.58	[a] 0.21	0.14
#2	1.63	1.45	1.64	1.50	1.61	[a] 0.19	0.14
September							
#3	1.60	1.39	1.77	1.54	1.56	[a] 0.38	0.14
#4	1.64	1.46	1.58	1.57	1.50	[a] 0.18	0.14
August							
#5	1.64	1.24	[b] —	1.81	1.65	[a] 0.57	0.13
#6	1.80	1.39	1.71	1.85	1.69	[a] 0.46	0.14
July							
#7	1.60	1.35	1.63	1.74	1.65	[a] 0.39	0.14
#8	1.61	1.39	1.44	1.71	1.57	[a] 0.32	0.14
June							
#9	1.47	1.38	1.56	—	1.52	[a] 0.18	0.13
#10	—	1.39	1.57	—	1.68	[a] 0.29	0.12
May							
#11	1.69	1.50	1.41	1.54	1.56	[a] 0.28	0.14
#12	1.57	1.37	1.47	1.46	1.48	[a] 0.20	0.14
April							
#13	1.49	1.40	1.60	1.54	1.42	[a] 0.20	0.14
#14	1.62	1.39	1.51	—	1.43	[a] 0.23	0.13

[a] Observed range greater than allowable range.
[b] Dash indicates no analysis performed.

not as important as the other radionuclide determinations and are in most cases a by-product of the gamma spectroscopic analysis of milk, the analytical capability for such an analysis should be improved. Accordingly, in September 1963, a program similar to that carried out for Cs^{137} was in preparation. Hopefully, this study will uncover the cause of the disagreement among the laboratories for potassium analysis and enable corrective measures to be taken.

Analytical variations are associated with radioanalysis, as with other types of measurement. In view of the uncertainties in the biological parameters that control the use of the data, the analytical differences described in this report were acceptable for radiological health purposes.

Summary

The data tabulated in this report for April–October 1963 show that the agreement among several DRH laboratories for I^{131} and Ba^{140} analyses in milk was acceptable at the low levels observed during that period according to the pre-selected limits of analytical agreement.

Results for the first part of this period for Cs^{137} indicated that improvement was needed. After appropriate steps were taken, data for the latter part of the period indicated improvement in the analytical agreement for Cs^{137}. Results of the entire period for potassium were not acceptable, and steps to bring about better agreement are being taken.

The cross-check analysis has proved to be a useful tool in demonstrating analytical competence and in pointing out analytical discrepancies. Future reports will be made periodically by the Analytical Quality Control Service in *RHD* to update the findings of the cross-check program.

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(*2*) Hoel, P. G.: *Introduction to Mathematical Statistics*, Wiley, New York (1958), pp. 241–242.

(*3*) American Society for Quality Control: *Guide for Quality Control and Control Chart Method of Analyzing Data, ASQC Standards B1 and B2*, American Standards Association, New York (1958), $1.00. p. 21 (table 2).

Correction for June 1964 Issue

The table below was inadvertently omitted from the June 1964 issue article entitled "Strontium–90 in Plant Parts and Milling Fractions From a 1963 Illinois Wheat," by V. F. Pfeifer, A. J. Peplinski and J. E. Hubbard, on pages 283–4.

TABLE 3.—STRONTIUM–90 IN MILLING FRACTIONS FROM FIELD-COMBINED WHEAT

[Analyses on dry basis]

Fraction	Yield (Percent)	Protein (Percent)	Ash (Percent)	Calcium (Percent)	Sr^{90} (pc/kg)	Sr^{90} in fraction (Percent of total)
Wheat		11.5	1.96	0.039	[a] 87.1	100
Patent flour	59.9	10.3	0.46	0.014	18.3	10
First clear flour	12.8	11.3	0.90	0.025	49.5	6
Second clear flour	2.9	13.6	2.08	0.040	77.1	2
Shorts	3.7	[b] 17.1	4.90	0.104	321	11
Bran	20.7	[b] 17.4	6.69	0.118	369	71

[a] Sr^{90} in wheat, calculated from milling fractions= 107.8.
[b] Nitrogen content x 6.25.

Section III—Water

RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, FEBRUARY 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this System has expanded to 130 stations as of July 1, 1964. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the System provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the System are published in annual compilations (*1–7*).

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, FEBRUARY 1964

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids and strontium–90 determinations on total solids are performed as frequently as deemed necesary.

Presently, gross alpha and beta determinations are made on monthly composites of the weekly samples received from most stations. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are also conducted at newly established stations for the first year of operation.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Results

Table 1 presents February 1964 results of alpha and beta analyses of U. S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first station listed being closest to the head-waters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the System's Annual Compilation of Data (*7*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 the mean is reported as <1 pc/liter. The most recent quarterly strontium–90 results appear in this issue on page 391.

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the February 1964 average total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Results for the years 1957–1962 have been summarized by Weaver *et al.* (*9*).

Discussion

The monthly dissolved beta activity averages exceeded 100 pc/liter only on the Columbia River, Clinch River and Red River, North. Of the six stations on the Columbia River, the four downstream from the Hanford Atomic Products Operations facility had averages of between 127 and 591 pc/liter. It can be observed that the concentration diminishes with distance downstream from the facility. Additional data on radioactivity in the Columbia River are presented and discussed in the articles on pages 386 and 395.

Dissolved alpha activity, which is associated with the dissolving of natural surface minerals by water reached a maximum observed monthly average of 40 pc/liter. Of all stations, five on different rivers had monthly average dissolved alpha activity greater than 10 pc/liter.

While there are no generally applicable standards for surface waters, the radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*10*). The Public Health Service Drinking Water Standards state that in the absence of

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, FEBRUARY 1964

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsburgh, Pa	6	7	13	0	0	0
Animas River:						
Cedar Hill, N. Mex	4	13	17	0	2	2
Apalachicola River:						
Chattahoochee, Fla	7	10	17	0	0	0
Arkansas River:						
Coolidge, Kansas	23	61	84	2	40	42
Ponca City, Okla	6	35	41	0	3	3
Fort Smith, Ark	11	33	44	1	4	5
Little Rock, Ark	14	21	35	<1	1	1
Pendleton Ferry, Ark	30	27	57	2	0	2
Bear River:						
Preston, Idaho	1	11	12	0	2	2
Big Horn River:						
Hardin, Mont	5	20	25	1	6	7
Big Sioux River:						
Sioux Falls, S. Dak	4	22	26	0	0	0
Chattahoochee River:						
Atlanta, Ga	5	6	11	0	0	0
Columbus, Ga	14	7	21	1	0	1
Lanett, Ala	5	6	11	1	0	1
Chena Slough:						
Fairbanks, Alaska	2	3	5	0	0	0
Clearwater River:						
Lewiston, Idaho	2	8	10	0	0	0
Clinch River:						
Clinton, Tenn	3	9	12	<1	0	<1
Kingston, Tenn	8	112	120	0	0	0
Colorado River:						
Loma, Colo	10	27	37	2	9	11
Page, Ariz	1	37	38	0	9	9
Boulder City, Nev	0	16	16	0	9	9
Parker Dam, Calif-Ariz	3	20	23	0	9	9
Yuma, Ariz	2	10	12	0	3	3
Columbia River:						
Northport, Wash	1	8	9	0	1	1
Wenatchee, Wash	0	13	13	0	1	1
Pasco, Wash	64	591	655	0	1	1
McNary Dam, Ore	24	355	279	0	1	1
Bonneville, Ore	32	234	266	0	1	1
Clatskanie, Ore	27	127	154	0	<1	<1
Connecticut River:						
Wilder, Vt	3	10	13	0	0	0
Northfield, Mass	6	9	15	0	0	0
Enfield Dam, Conn	2	10	12	0	0	0
Cuyahoga River:						
Cleveland, Ohio	2	29	31	0	0	0
Delaware River:						
Martins Creek, Pa	2	9	11	0	0	0
Trenton, N. J	3	5	8	1	0	1
Philadelphia, Pa	15	11	26	1	1	2
Escambia River:						
Century, Fla	4	6	10	0	0	0
Great Lakes:						
Duluth, Minn	1	4	5	0	0	0
Sault Ste. Marie, Mich	2	6	8	0	0	0
Milwaukee, Wisc	1	6	7	0	0	0
Gary, Ind	5	8	13	0	0	0
Port Huron, Mich	1	7	8	0	0	0
Detroit, Mich	0	8	8	0	0	0
Buffalo, New York	2	16	18	0	0	0
Green River:						
Dutch John, Utah	0	33	33	0	2	2
Hudson River:						
Poughkeepsie, N. Y	5	12	17	0	0	0
Illinois River:						
Peoria, Ill	10	16	26	2	0	2
Grafton, Ill	8	24	32	0	3	3
Kanawha River: Winfield Dam, W. Va	5	5	10	0	0	0
Kansas River:						
De Soto, Kansas	8	29	36	0	4	4
Klamath River:						
Keno, Oreg	5	14	19	0	0	0
Little Miami River:						
Cincinnati, Ohio	7	22	29	0	1	1
Maumee River:						
Toledo, Ohio	7	24	31	<1	0	<1
Merrimack River:						
Lowell, Mass	2	13	15	0	0	0
Mississippi River:						
St. Paul, Minn	2	20	22	0	1	1
Dubuque, Iowa	1	16	17	0	0	0
Burlington, Iowa	4	19	23	0	1	1
E. St. Louis, Ill	7	20	27	0	2	2
Cape Girardeau, Mo	11	19	30	0	1	1
W. Memphis, Ark	18	13	31	2	1	3
Vicksburg, Miss	30	19	49	3	0	3
Delta, La	19	15	34	5	2	7
New Orleans, La	11	14	25	1	1	2
Missouri River:						
Williston, N. Dak	8	18	26	1	4	5
Bismarck, N. Dak	6	30	36	0	3	3
Yankton, S. Dak	10	24	34	1	8	9
Omaha, Nebr	3	21	24	1	4	5
St. Joseph, Mo	1	20	21	0	5	5
Kansas City, Kans	14	24	38	1	11	12
Missouri City, Mo	8	21	29	0	4	4
St. Louis, Mo	12	24	36	0	1	1
Monongahela River:						
Pittsburgh, Pa	3	7	10	0	0	0
North Platte River:						
Henry, Nebr	5	33	38	0	32	32
Ohio River:						
Toronto, Ohio	2	8	10	0	0	0
Addison, Ohio	2	8	10	0	0	0
Huntington, W. Va	7	7	14	0	0	0
Cincinnati, Ohio	9	9	18	1	0	1
Louisville, Ky	9	7	16	1	0	1
Evansville, Ind	8	10	18	2	0	2
Cairo, Ill	29	11	40	8	1	9
Ouachita River:						
Bastrop, La	30	19	49	1	3	4
Pend Oreille River:						
Albeni Falls Dam, Idaho	1	7	8	0	0	0
Platte River:						
Plattsmouth, Nebr	16	21	37	1	8	9
Potomac River:						
Williamsport, Md	6	6	12	0	0	0
Great Falls, Md	9	8	17	0	0	0
Washington, D.C	3	7	10	<1	0	<1
Rainy River:						
Baudette, Minn	3	28	31	1	0	1
International Falls, Minn	1	30	31	0	0	0
Raritan River:						
Perth Amboy, N. J. (5 ft. Below Surface)	2	10	12	0	1	1
Perth Amboy, N. J. (5 ft. Above Bottom)	4	9	13	0	3	3
Red River, North:						
Grand Forks, N. Dak	17	139	156	1	3	4
Red River, South:						
Denison, Tex	3	48	51	0	2	2
Index, Ark	3	31	34	0	4	4
Bossier City, La	11	22	33	1	0	1
Alexandria, La	11	21	32	2	2	4
Rio Grande River:						
Alamosa, Colo	0	5	5	1	0	1
El Paso, Tex	1	18	19	0	4	4
Laredo, Tex	17	24	41	0	4	4
Brownsville, Tex	5	31	36	0	4	4
Roanoke River:						
John H. Kerr Resr/ Dam, Va	6	9	15	0	0	0
Sabine River:						
Ruliff, Tex	12	22	34	0	0	0
Sacramento River:						
Courtland, Calif	1	6	7	0	0	0
San Joaquin River:						
Vernalis, Calif	3	19	22	0	5	5
San Juan River:						
Shiprock, N. Mex	11	34	45	2	15	17
Savannah River:						
North Augusta, S. C	11	19	30	0	0	0
Port Wentworth, Ga	7	18	25	<1	0	<1
Schuylkill River:						
Philadelphia, Pa	1	8	9	0	0	0
Shenandoah River:						
Berryville, Va	2	6	8	0	0	0
Ship Creek:						
Anchorage, Alaska	1	1	2	0	0	0
Snake River:						
Ice Harbor Dam, Wash	2	12	14	0	2	2
Wawawai, Wash	6	12	18	0	3	3
Payette, Idaho	3	16	19	0	4	4
South Platte River:						
Julesburg, Colo	30	57	87	5	40	45
Spokane River:						
Post Falls Dam, Idaho	2	6	8	0	0	0
Susquehanna River:						
Sayre, Pa	1	8	9	0	0	0
Conowingo, Md	1	7	8	0	0	0
Tennessee River:						
Lenoir City, Tenn	5	8	13	0	0	0
Chattanooga, Tenn	7	20	27	<1	<1	<1
Bridgeport, Ala	3	15	18	0	0	0
Pickwick Landing, Tenn	6	16	22	0	0	0
Tombigbee River:						
Columbus, Miss	10	17	27	1	0	1
Truckee River:						
Farad, Calif	1	6	7	0	0	0
Verdigris River:						
Nowata, Okla	10	40	50	0	1	1
Wabash River:						
New Harmony, Ind	9	22	31	0	<1	<1
Willamette River:						
Portland, Oreg	3	3	6	0	0	0
Yakima River:						
Richland, Wash	1	7	8	0	1	1
Yellowstone River:						
Sidney, Mont	2	18	20	1	5	6
Maximum	64	591	655	8	40	45
Minimum	0	1	2	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the network's Annual Compilation of Data (7).

strontium–90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1000 pc/liter (*11*).

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(*11*) Public Health Service: *Drinking Water Standards, Revised 1962, Public Health Service Publication No. 956*, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (March 1963), price 30 cents.

[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium–90, respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education and Welfare, Washington, D. C. 20201.

RADIOACTIVITY IN WASHINGTON SURFACE WATER[1] JULY 1962—JUNE 1963

Robert R. Mooney and Peter W. Hildebrandt[2]

Radioanalysis of surface water samples collected throughout the State of Washington is one of the major functions of the Washington State Department of Health radiation surveillance program. Surface water samples are usually collected on a quarterly schedule from 71 stations located on 65 rivers throughout the State. These samples are collected by the Washington Pollution Control Commission, and are sent to the Department of Health for radiological analyses. A few other locations are sampled less frequently, and selected stations on the Columbia River[3] are sampled weekly by local health department sanitarians.

Sampling and Analytical Procedures

All surface water samples are collected as grab samples in 2-liter plastic bottles. Two milliliters of concentrated nitric acid are added to the sample before shipment to the laboratory to prevent loss of activity to the container.

Surface water samples are placed in stainless steel Marinelli beakers for the gamma scans. Distilled water is added when necessary to obtain 2-liter volumes for standardizing counting geometry. These samples are gamma scanned for 100 minutes approximately two weeks after collection. This two-week period permits the decay of short-lived isotopes (Na^{24}, As^{76}, Np^{239}) in Columbia River water samples. The matrix method, utilizing a 4 x 4 matrix, permits the quantative determination of Cr^{51}, Ru^{106}, Zr^{95}, and Zn^{65}. Results are extrapolated to the date of collection.

The counting equipment consists of a 3 x 3-inch gamma scintillation crystal and 512–channel analyzer. A one-minute count each day of a cesium–137 standard is performed as an efficiency check and a ten-minute count each week is done to check the resolution. An 800–minute count each week is taken to check the background. Table 1 gives the gamma efficiencies and detectability limits for this system.

After the gamma scan, the water samples receive further preparation and are beta counted for suspended and soluble radioactivity. The separation of dissolved and suspended activity is accomplished by filtering the sample (What-

[1] Summarized from *Environmental Radiation Surveillance in Washington State*, (*1*).

[2] Mr. Mooney is Engineer and Mr. Hildebrandt is Technical Director, Air and Radiation Control Section, State Department of Health, Seattle, Washington.

[3] For other data concerning the Columbia River see page 395 of this issue.

FIGURE 1.—WASHINGTON SURFACE WATER SAMPLING LOCATIONS WITH CODE NUMBERS

man #42 filter paper). The filtrate, evaporated to near dryness, is quantitatively transferred to a tared planchet and dried for gross beta counting. The filter paper containing the suspended activity is ashed in a muffle furnace at 600°C and plancheted for gross beta counting. After obtaining the net beta counting rate, corrections for self absorption are made and the results converted to concentrations in water. Beta results are not extrapolated to date of collection.

TABLE 1.—GAMMA EFFICIENCIES AND DETECTABILITY LIMITS FOR THE WASHINGTON STATE ANALYSES

Radionuclide	Energy band (Mev)	Efficiency (%)	Average background (pc)	Detectability limits (pc)
Cr^{51}	0.30–0.36	0.45	2,800	220
Ru^{106}	0.44–0.56	0.94	1,360	109
Zr^{95}	0.73–0.79	6.00	60	10
Zn^{65}	1.05–1.17	0.94	370	59

Through May 1963, beta counting was performed in an internal proportional gas-flow counter with an average background of 12.5 counts per minute. Since that time, beta counting has been done with a low background beta system including a 2-inch detector and automatic sample changer. This system has an average background of 0.5 counts per minute. One-hour background counts are performed daily. Calibration of the instrument is done with a Sr^{90}–Y^{90} standard.

Results

Table 2 presents the monthly average results for the two Columbia River stations which are sampled routinely. In averaging, a less-than value is assumed to be equal to the full value. Samples from this river are generally gamma scanned for four radionuclides (Cr^{51}, Ru^{106}, Zr^{95}, Zn^{65}), following which the suspended and dissolved solids are each analyzed for total beta activity.

Samples from other rivers are analyzed for total beta activity of the dissolved and of the suspended fractions. Table 3 summarizes all analyses of the 65 locations from July 1962 through June 1963. The first column in this table gives code numbers and the abbreviations denoting geographical sections (in figure 1). Each river is assigned a number and if more than one station is located on that river, lower case letters are used to designate these stations. For example, code number 21 refers to the Green River sampling station in the area desig-

TABLE 2.—MONTHLY AVERAGE RADIOACTIVITY IN COLUMBIA RIVER WATER, OCTOBER 1962-JUNE 1963

[Concentrations in pc/liter]

Sampling and type of sample	Oct. 62	Nov. 62	Dec. 62	Jan. 63	Feb. 63	Mar. 63	Apr. 63	May 63	June 63
Pasco (Code No. 68)									
Beta									
Suspended	[a] —	—	—	—	48	79	207	44	33
Dissolved	—	—	—	—	150	389	230	83	32
Total	—	—	—	—	198	468	437	127	65
Gamma									
Chromium-51	—	—	—	—	4,900	10,060	6,720	3,200	2,430
Ruthenium-106	—	—	—	—	250	120	76	<50	<50
Zirconium-95	—	—	—	—	6	15	6	<5	<5
Zinc-65	—	—	—	—	249	479	404	249	133
Vancouver (Code No. 66)									
Beta									
Suspended	18	—	48	22	30	27	29	29	18
Dissolved	61	—	70	75	61	83	120	63	20
Total	79	—	118	97	91	110	149	92	38
Gamma									
Chromium-51	3380	—	2460	2200	1840	2690	3000	2030	1500
Ruthenium-106	<50	—	<50	<50	75	55	<50	<50	<50
Zirconium-95	<5	—	<5	5	10	5	5	<5	<5
Zinc-65	35	—	50	73	71	77	118	73	75
Washougal (Code No. 67)									
Beta									
Suspended	—	—	49	27	42	27	40	27	21
Dissolved	—	—	53	75	83	94	140	53	24
Total	—	—	102	102	125	121	180	80	45
Gamma									
Chromium-51	—	—	2560	2360	2130	2950	3330	2070	1580
Ruthenium-106	—	—	<50	<50	69	<50	<50	<50	<50
Zirconium-95	—	—	<5	<5	14	<5	10	<5	<5
Zinc-65	—	—	52	81	82	95	98	83	83

[a] Dash indicates no samples taken.

nated "PS", i.e. Puget Sound. The third column gives the total number of samples analyzed. Some samples (four) had analyses performed only on either suspended or dissolved solids. Twenty samples had analyses performed on the total solids only. Less-than values are assigned the full value in averaging.

The network summary gives the maximum and minimum value for the 274 samples analyzed, while the network average is obtained by averaging all the station average values.

Discussion

Of the 274 river water samples analyzed during July 1962 through June 1963 (excluding the Columbia River), the total beta activity ranged from 3 to 164 pc/liter with an average of 24.0 pc/liter. The activity of soluble fraction was somewhat lower, ranging from 2 to 101 pc/liter and averaging 16.6 pc/liter.

The following observations apply to the period December 1962 through July 1963, when continued surveillance was in progress: monthly average total beta activity for the Columbia River stations ranged from 38 to 180 pc/liter. The gamma emitters Ru^{106} and Zr^{95} were found in Columbia River water with monthly average concentrations ranging from <50 to 75 pc/liter for Ru^{106} and <5 to 14 pc/liter for Zr^{95}. The values for Ru^{106} are probably representative of a combination of Ru^{103} and Ru^{106}. The radionuclides Ru^{106} and Zr^{95} were found in other river basins as well as in the Columbia River. Two other gamma emitting radionuclides, Cr^{51} and Zn^{65}, were found in detectable quantities only in Columbia River water. Monthly averages for Cr^{51} ranged from 1499 to 3329 pc/liter and for Zn^{65} the range was 50 to 118 pc/liter.

Although any standards for gross beta activity must be very carefully applied, the standard for drinking water is 1000 pc/liter of beta activity in the absence of strontium–90 and alpha emitters (*2*). The standards for water from all dietary sources for the general population at large (*3*) are:

Cr^{51}, 670,000 pc/liter; Ru^{106}, 3,300 pc/liter; Zr^{95}, 20,000 pc/liter; Zn^{65}, 10,000 pc/liter.

REFERENCES

(*1*) Mooney, R. R. and P. W. Hildebrandt: *Environmental Radiation Surveillance in Washington State*, Washington State Department of Health, Olympia, Washington, Limited Distribution (August 1963).

TABLE 3.—BETA ACTIVITY IN WASHINGTON SURFACE WATER, JULY 1962-JUNE 1963

Code number and area	Sampling location (river)	Number of samples	Suspended			Dissolved			Total		
			Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum
1 SC	American	3	11	<1	30	13	3	33	24	4	63
2 NW	Baker	3	7	2	11	25	20	31	32	22	42
3 PS	Big Quiliene	3	1	<1	1	4	2	8	5	3	9
4 SC	Bumping	3	2	<1	2	10	7	15	12	9	16
5 PS	Cedar	12	9	<1	36	24	3	57	31	3	93
6 NE	Chamokane	2	7	6	7	11	4	17	18	10	24
7 CP	Chehalis	6	4	<1	10	11	4	18	16	5	28
8 NC	Chelan	4	3	<1	5	9	4	12	12	5	18
9 CP	Cloquallam	4	2	<1	3	16	4	26	15	3	29
10 NE	Colville	6	6	2	13	12	5	26	18	9	39
11 SW	Coweman	4	24	1	47	17	12	24	32	3	59
12 SW	Cowlitz	3	3	1	6	12	5	19	15	6	25
13 SC	Crab	4	5	3	8	17	8	23	21	13	28
14 PS	Deschutes	4	3	<1	6	8	4	16	11	5	22
15 PS	Dosewallips	2	3	2	3	8	7	8	10	10	10
16 PS	Duckabush	3	2	<1	3	6	4	7	7	5	8
17 CP	Dungeness	3	1	<1	2	6	4	8	7	5	10
18 PS	Duwamish	4	10	<1	20	18	4	32	28	5	52
19 CP	Elwha	3	1	<1	2	6	5	7	7	6	9
20 NC	Entiat	4	3	<1	8	9	2	17	12	3	25
21 PS	Green	5	5	<1	12	14	2	23	17	3	27
22 PS	Hamma Hamma	3	1	<1	<1	5	4	6	6	5	7
23 CP	Hoh	3	3	<1	4	9	3	13	12	4	17
24 CP	Humptulips	4	3	<1	9	11	3	20	14	4	28
25 SW	Kalama	4	11	<1	21	16	4	24	21	3	40
26 NE	Kettle	3	15	3	27	11	11	11	12	10	14
27 SC	Little Naches	3	9	<1	23	11	4	25	20	6	48
28 NE	Little Spokane	4	9	<1	16	17	10	28	19	3	44
29 NC	Methow	4	3	<1	6	9	6	14	12	7	20
30a SC	Naches	3	9	6	11	8	3	11	17	13	22
30b SC	Naches	4	4	<1	8	8	4	10	12	5	18
31 SW	Newaukum	3	5	<1	9	11	8	14	12	3	23
32 PS	Nisqually	4	6	1	11	15	7	26	21	8	37
33 NW	Nooksak	4	27	6	64	32	8	49	59	14	113
34 PS	N. Stillaguamish	4	19	9	26	43	35	47	48	6	73
35a NC	Okanogan	4	5	<1	13	17	9	30	22	10	43
35b NC	Okanogan	4	7	<1	13	16	8	30	23	9	43
36 SE	Palouse	3	13	4	31	30	20	50	22	24	81
37 a NE	Pend Oreille	3	4	2	7	31	16	38	35	20	45
37 b NE	Pend Oreille	4	15	<1	33	19	15	22	27	16	55
38 PS	Puyallup	4	4	2	7	17	14	21	21	17	24
39 CP	Queets	3	3	<1	7	7	3	14	10	4	21
40 SC	Rattlesnake	3	9	<1	26	9	5	15	18	6	41
41 NW	Samish	4	11	5	16	33	18	46	34	3	62
42 NE	Sanpoil	3	3	1	4	16	8	30	44	9	33
43 PS	Sammamish	4	14	<1	46	15	7	19	29	8	64
44 CP	Satsop	4	5	<1	16	13	2	45	18	3	61
45 NC	Similkameen	4	3	<1	6	13	10	14	16	14	19
46 NW	Skagit	4	9	2	12	25	10	34	34	12	46
47 PS	Skokomish	3	4	<1	9	7	3	12	11	4	21
48 PS	Skykomish	3	10	6	18	48	27	85	58	33	103
49a SE	Snake	4	10	3	20	20	11	30	28	14	48
49b SE	Snake	4	10	1	16	20	14	30	30	15	38
50 PS	Snakomish	4	9	<1	16	20	3	29	29	4	43
51 PS	Snoqualimie	4	16	<1	40	29	4	48	45	5	88
52 CP	Soleduck	2	1	<1	1	6	4	7	7	5	8
53 PS	S. Stillaguamish	4	12	<1	20	35	7	55	47	8	73
54a NE	Spokane	4	7	1	13	19	19	20	21	21	33
54b NE	Spokane	4	5	1	13	22	10	36	22	11	38
55 PS	Stillaguamish	4	16	<1	27	36	5	58	52	6	79
56 PS	Stuck	4	3	<1	5	21	7	43	24	9	47
57 PS	Sultan	4	14	<1	30	39	3	94	53	4	124
58 SC	Teanaway	4	8	<1	21	8	3	14	16	4	35
59 SC	Tieton	2	8	7	9	11	10	11	19	17	20
60 PS	Tolt	4	23	<1	63	38	2	101	61	3	164
61 SW	Toutle	4	7	<1	10	17	7	27	19	4	36
62 SE	Walla Walla	4	6	<1	19	13	7	22	19	8	32
63a NC	Wenatchee	4	2	<1	3	13	4	26	15	5	29
63b NC	Wenatchee	3	8	<1	10	15	11	18	23	12	26
64 CP	Wynoochee	4	15	<1	56	4	2	6	19	3	58
65 SC	Yakima	11	7	<1	23	13	6	31	20	7	41
Network summary		274	7.8	<1	64	16.6	2	101	23.0	3	164

(2) Public Health Service: *Public Health Service Drinking Water Standards, PHS No. 956* (Reprinted August 1963), Superintendent of Documents, Washington, D. C. 20402, price 30 cents.

(3) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

TRENDS OF STRONTIUM-90 LEVELS IN SURFACE WATERS OF THE UNITED STATES, 1959—1963

Earl P. Floyd and Leo Weaver[1]

Radioactivity levels in surface waters of the major river basins have been monitored by the Public Health Service Water Pollution Surveillance System since 1957. However, strontium–90 determinations did not begin until 1959.

Initially, strontium–90 analyses of total solids were made quarterly on three-month composites of aliquots from weekly samples. Beginning in November 1962, the frequency of analysis was reduced to two quarterly samples per year at each sampling point except those stations immediately below nuclear installations, where quarterly analyses were continued.

Through September 1961, the method used for determining strontium–90 was that described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*1*). Tributyl phosphate was used to extract ingrown yttrium–90 from the purified, coprecipitated strontium–90. Beginning in October 1961, a modification of a procedure described by Harley has been used (*2*). The yttrium–90 together with an yttrium carrier is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background anticoincidence, end-window proportional counter.

Results

Table 1 presents the results of quarterly analyses of strontium–90 concentrations in U. S. surface waters from October 1962 through December 1963. The stations are arranged in the table according to their relative location on the river, the first station listed being closest to the head-waters.

In order to summarize all the quarterly strontium–90 in surface water results, figure 1 shows the trend of the strontium–90 averages observed in the Surveillance System from 1959 through 1963.

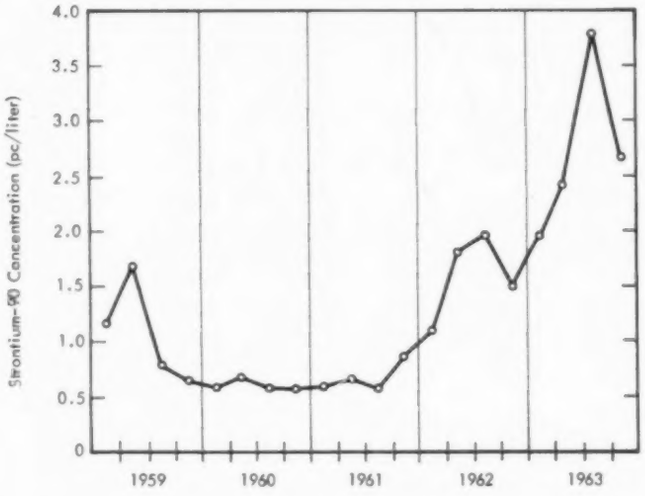

FIGURE 1.—NETWORK AVERAGE STRONTIUM–90 CONCENTRATIONS (QUARTERLY MEANS) IN SURFACE WATERS

Discussion

Completion of analyses on quarterly composites of weekly samples for the last half of 1963 revealed a sharp increase during July–September followed by a decline during October–December of the strontium–90 levels in surface waters of the North Central area of the conterminous States (see figure 2). This trend, as well as the relationship between the National average and the North Central average strontium–90 concentration, is shown in table 2. It is observed that the North Central area mean is ⅓ to ½ greater than the national mean during the last half of 1963. For comparison, the results for July–September 1961 are included since they represent essentially background levels. Chronological trends are similar; the highest values recorded during July–September 1963 are in the North Central area. This may also be seen in figure 2, which shows the maximum, minimum, and average strontium–90 concentrations in surface waters in different river basins for the period July–September 1963.

The highest quarterly strontium–90 value for any station in the system recorded to date is 12.6 pc/liter; this occurred in the Clinch River.

[1] Mr. Floyd is Radiochemist and Mr. Weaver is Chief, Water Quality Section, Basic Data Branch, Division of Water Supply & Pollution Control, Public Health Service, 1014 Broadway, Cincinnati, Ohio 45226.

TABLE 1.—QUARTERLY AVERAGE STRONTIUM-90 CONCENTRATIONS IN SURFACE WATERS, OCTOBER 1962–DECEMBER 1963

[Concentrations in pc/liter]

Station	Oct.–Dec. 1962	Jan.–Mar. 1963	Apr.–June 1963	July–Sept. 1963	Oct.–Dec. 1963
Allegheny River:					
Pittsburgh, Pa	1.8	[a]—	1.8	—	2.8
Animas River:					
Cedar Hill, N. Mex	0.9	—	—	1.8	—
Apalachicola River:					
Chattahoochee, Fla	0.9	—	—	2.9	—
Arkansas River:					
Coolidge, Kans	1.0	1.0	—	6.6	—
Ponca City, Okla	2.2	—	5.9	6.5	4.4
Fort Smith, Ark	—	—	—	6.7	—
Little Rock, Ark	—	—	—	4.8	4.4
Pendleton Ferry, Ark	—	—	5.5	—	4.3
Bear River:					
Preston, Idaho	0.9	—	—	3.7	—
Big Horn River:					
Hardin, Mont	1.3	—	5.8	—	2.3
Big Sioux River:					
Sioux Falls, S. Dak	2.5	—	—	9.5	5.0
Chattahoochee River:					
Atlanta, Ga	1.0	3.6	1.6	—	1.7
Columbus, Ga	1.1	—	1.5	—	1.7
Lanett, Ala	0.8	—	—	2.0	—
Chena Slough:					
Fairbanks, Alaska	0.3	—	0.7	—	0.2
Clearwater River:					
Lewiston, Idaho	0.4	—	—	1.2	—
Clinch River:					
Clinton, Tenn	1.0	—	—	1.4	—
Kingston, Tenn	—	6.3	5.6	9.4	6.5
Colorado River:					
Loma, Colo	0.5	—	2.5	—	1.4
Page, Ariz	6.9	1.5	—	4.2	—
Boulder City, Nev	1.5	—	1.8	—	1.5
Parker Dam, Calif-Ariz	1.3	—	—	1.0	—
Yuma, Ariz	0.9	—	0.9	—	1.1
Columbia River:					
Northport, Wash	0.9	—	—	3.4	—
Wenatchee, Wash	1.6	—	1.1	—	2.8
Pasco, Wash	1.5	2.3	2.4	2.7	3.4
McNary Dam, Ore	1.0	1.4	1.1	2.6	2.5
Bonneville, Ore	1.2	—	—	1.2	—
Clatskanie, Ore	0.9	—	1.3	2.5	1.6
Connecticut River:					
Wilder, Vt	0.9	—	—	2.6	—
Northfield, Mass	1.0	—	1.4	3.1	1.8
Enfield Dam, Conn	1.0	—	—	2.5	—
Cumberland River:					
Clarksville, Tenn	—	—	—	2.0	—
Cuyahoga River:					
Cleveland, Ohio	—	1.4	—	5.3	—
Delaware River:					
Martins Creek, Pa	1.2	—	1.7	—	1.6
Trenton, N. J	0.9	—	—	3.1	—
Philadelphia, Pa	2.4	—	1.1	—	2.1
Escambia River:					
Century, Fla	—	—	1.4	—	1.2
Great Lakes:					
Duluth, Minn	0.7	—	0.4	—	0.7
Sault Ste. Marie, Mich	0.8	—	—	1.5	—
Milwaukee, Wisc	0.8	—	0.8	—	0.8
Gary, Ind	0.7	—	—	1.6	—
Port Huron, Mich	0.8	—	1.3	—	1.2
Detroit, Mich	1.1	—	—	2.4	—
Buffalo, N. Y	1.7	—	2.2	—	2.5
Green River:					
Dutch John, Utah	1.2	—	—	2.7	—
Hudson River:					
Poughkeepsie, N. Y	3.0	—	3.8	—	5.0
Illinois River:					
Peoria, Ill	1.7	—	3.5	—	2.3
Grafton, Ill	1.8	—	—	4.4	—
Kanawha River:					
Winfield Dam, W. Va	1.1	—	—	2.9	—
Kansas River:					
De Soto, Kans	—	—	4.9	7.4	5.2
Klamath River:					
Keno, Ore	0.9	—	1.4	—	1.8
Little Miami River:					
Cincinnati, Ohio	1.6	—	—	5.3	1.4
Maumee River:					
Toledo, Ohio	—	3.6	4.9	—	2.7
Merrimack River:					
Lowell, Mass	0.9	—	—	1.6	—
Mississippi River:					
St. Paul, Minn	3.4	—	—	7.2	4.3
Dubuque, Iowa	2.6	—	4.2	—	3.7
Burlington, Iowa	2.1	—	—	7.3	4.3
E. St. Louis, Ill	1.8	—	4.0	—	3.8
Cape Girardeau, Mo	2.7	—	—	5.3	—
W. Memphis, Ark	2.0	—	3.6	—	3.6
Vicksburg, Miss	2.0	—	—	4.2	—
Delta, La	2.1	—	3.3	—	3.4
New Orleans, La	1.9	—	—	4.5	—
Missouri River:					
Williston, N. Dak	1.5	—	2.5	—	2.8
Bismarck, N. Dak	1.7	—	—	3.5	—
Yankton, S. Dak	2.3	—	3.3	—	3.3
Omaha, Nebr	2.5	—	—	4.5	—
St. Joseph, Mo	1.9	—	6.2	—	3.4
Kansas City, Kans	3.4	—	—	5.0	—
Missouri City, Mo	2.6	—	4.1	—	4.1
St. Louis, Mo	2.7	—	—	6.2	—
Monongahela River:					
Pittsburgh, Pa	1.5	—	2.7	3.3	3.3
North Platte River:					
Henry, Nebr	0.6	1.1	2.5	—	0.7
Ohio River:					
Addison, Ohio	2.1	—	—	4.0	—
Huntington, W. Va	1.6	—	1.9	—	3.0
Cincinnati, Ohio	1.6	—	—	3.7	—
Louisville, Ky	1.4	—	2.3	3.6	4.0
Evansville, Ind	1.6	—	—	4.2	—
Cairo, Ill	1.7	—	2.9	—	2.8
Toronto, Ohio	—	—	—	4.9	2.8
Ouachita River:					
Bastrop, La	1.6	—	—	4.5	—
Pend Oreille River:					
Albeni Falls Dam, Idaho	0.7	—	0.9	—	1.3
Platte River:					
Plattsmouth, Nebr	2.3	—	—	5.2	—
Potomac River:					
Williamsport, Md	1.6	—	1.4	—	1.7
Great Falls, Md	1.0	—	—	2.5	—
Washington, D. C	—	—	—	3.4	—
Rainy River:					
Baudette, Minn	2.2	—	2.5	4.7	4.1
International Falls, Minn	1.8	—	2.9	4.3	3.8
Raritan River:					
Perth Amboy, N. J. (5-ft. Below Surface)	—	—	—	—	—
Perth Amboy, N. J. (5-ft. Above Bottom)	—	—	—	—	—
Red River, North:					
Grand Forks, N. Dak	—	—	—	11.3	7.1
Red River, South:					
Denison, Tex	5.0	—	—	5.6	—
Index, Ark	3.3	—	5.3	4.9	4.3
Bossier City, La	2.0	—	—	5.0	—
Alexandria, La	3.9	—	4.0	—	4.1
Rio Grande River:					
Alamosa, Colo	0.5	—	1.1	—	0.8
El Paso, Tex	0.7	—	—	1.9	—
Laredo, Tex	1.8	—	3.7	—	2.4
Brownsville, Tex	1.3	—	—	2.3	—
Roanoke River:					
John H. Kerr Resr/Dam, Va	1.1	—	1.3	—	2.6
Sabine River:					
Ruliff, Tex	1.4	—	—	3.2	—
Sacramento River:					
Courtland, Calif	0.9	—	—	1.4	1.0
St. Lawrence River:					
Massena, N. Y	1.2	—	—	2.3	—
San Joaquin River:					
Vernalis, Calif	1.0	—	1.3	—	1.5
San Juan River:					
Shiprock, N. Mex	1.7	1.5	1.9	—	2.1
Savannah River					
North Augusta, So. Car	0.6	—	—	2.1	—
Port Wentworth, Ga	1.5	2.4	2.2	3.2	2.4
Schuylkill River:					
Philadelphia, Pa	1.3	—	—	3.7	—
Shenandoah River:					
Berryville, Va	0.8	—	1.2	—	1.0
Ship Creek:					
Anchorage, Alaska	0.3	—	—	0.9	—
Snake River:					
Ice Harbor Dam, Wash	1.6	—	—	1.3	—
Wawawai, Wash	0.7	—	0.9	—	0.7
Payette, Idaho	0.8	—	1.5	—	0.8
South Platte River:					
Julesburg, Colo	0.8	0.8	1.7	—	1.8
Spokane River:					
Post Falls, Idaho	0.8	—	—	1.2	—
Susquehanna River:					
Sayre, Pa	1.0	—	—	2.3	—
Conowingo, Md	1.2	—	1.6	—	3.0
Tennessee River:					
Lenoir City, Tenn	1.0	—	1.5	—	2.1
Chattanooga, Tenn	1.4	2.6	1.7	3.3	2.2
Bridgeport, Ala	1.0	—	1.6	—	2.2
Pickwick Landing, Tenn	1.4	—	—	2.5	—
Tombigbee River:					
Columbus, Miss	0.6	—	—	3.6	—
Truckee River:					
Farad, Calif	0.9	—	1.0	—	1.0
Verdigris River:					
Nowata, Okla	2.5	—	4.2	—	6.0
Wabash River:					
New Harmony, Ind	1.4	—	3.1	—	2.5
Willamette River:					
Portland, Ore	0.6	—	0.7	—	0.5
Yakima River:					
Richland, Wash	0.4	—	—	1.0	—
Yellowstone River:					
Sindey, Mont	2.0	—	—	5.0	—
Maximum	6.9	6.3	6.2	11.3	7.1
Minimum	0.3	0.8	0.4	0.9	0.2

[a] Dash indicates no sample collected.

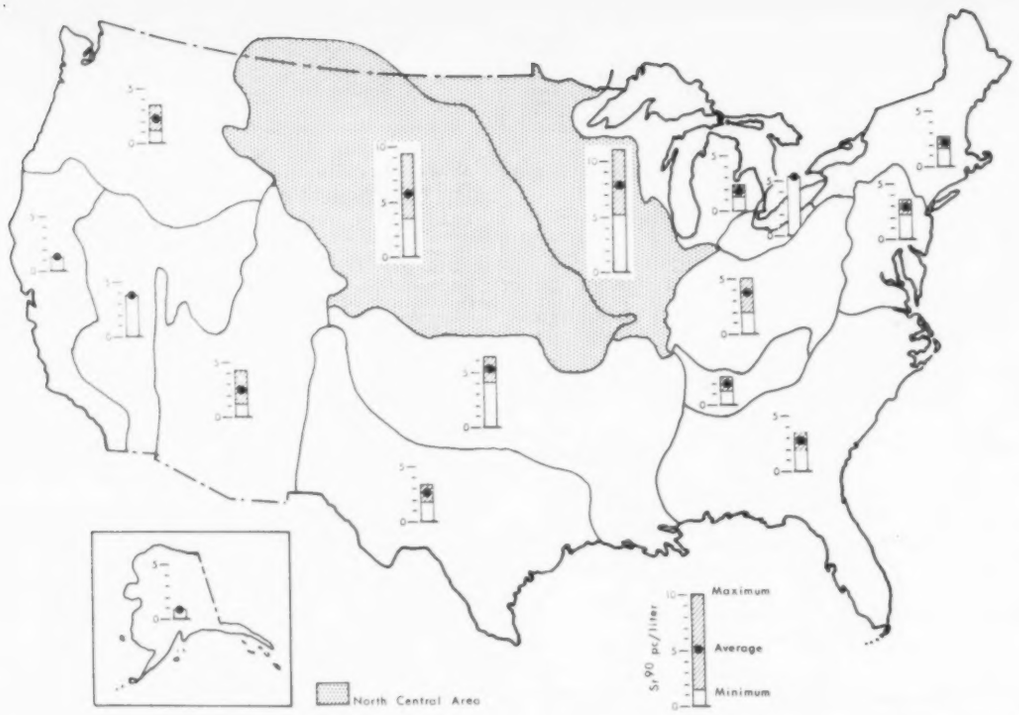

FIGURE 2.—DELINEATION OF THE NORTH CENTRAL AREA AND AVERAGE MAXIMUM AND MINIMUM STRONTIUM-90 CONCENTRATIONS IN SURFACE WATERS OF THE MAJOR RIVER BASINS, JULY-SEPTEMBER 1963

TABLE 2.—QUARTERLY AVERAGE STRONTIUM-90 LEVELS IN SURFACE WATER OF THE UNITED STATES

Period	National		North Central Area of U.S.	
	Number of samples	Strontium-90 (pc/liter)	Number of samples	Strontium-90 (pc/liter)
1961				
July-September	39	0.6	7	0.9
1963				
July-September	67	3.8	17	6.0
October-December	73	2.7	17	3.9

The second largest value, 11.3 pc/liter, was recorded for the sampling stations on the Red River of the North at Grand Forks, N. Dakota, during July–September 1963. The previously reported highest value (excluding the Clinch River value) of strontium–90 in the Surveillance System data was a 6.4 pc/liter concentration for the April–June 1962 composite from the Big Horn River at Hardin, Montana. Eight of the July–September 1963 composite sample determinations indicated results higher than 6.4 pc/liter. This does not include the 9.4 pc/liter results obtained on the Clinch River at Kingston, Tennessee, below the Oak Ridge National Laboratory, omitted so that the reported averages would indicate only the occurrence of strontium–90 due to fallout persisting from previous atmospheric nuclear detonations and possibly that supplemented by venting of recent underground tests at the Nevada Test Site (*3*). The eight sampling stations having values greater than this previously observed highest value of 6.4 pc/liter are listed in table 3. Total beta values (quarterly mean of monthly means of weekly samples) are listed for comparative purposes.

The PHS drinking water standards for radioactivity (*4*) give concentration limits and list a range of intake limits as set forth by the Federal Radiation Council (FRC). The limit for strontium–90 concentrations in drinking water is 10 pc/liter. While FRC range II daily intake rate for strontium–90 from all sources is 200 pc/day, daily intakes are prescribed with the provision that dose rates be averaged over a period of one year. The single value at Grand Forks in excess of 10 pc/liter can be considered a quarterly average in the raw water. It was not possible to calculate the annual average at Grand Forks because of the lack of previous samples. It is reasonable to assume, however,

that this annual average is less than 10 pc/liter in light of the decreased level determined for the subsequent quarter and lower results found in samples from other surface streams in the north central area. Further, it is known that strontium–90 levels are reduced through water treatment processes such as elevation of pH and lime-soda softening.

TABLE 3.—QUARTERLY AVERAGE STRONTIUM-90 AND TOTAL BETA ACTIVITY AT THE EIGHT SAMPLING STATIONS WHOSE STRONTIUM-90 CONCENTRATIONS EXCEEDED 6.4 pc/liter, [a] JULY–DECEMBER 1963

[Concentrations in pc/liter]

Sampling stations	Strontium-90		Gross Beta	
	July-September	October-December	July-September	October-December
Arkansas River:				
Coolidge, Kans	6.6	—	658	46
Ponca City, Okla	6.5	4.4	208	115
Ft. Smith, Ark	6.7	—	252	67
Big Sioux River:				
Sioux Falls, S. Dak	9.5	5.0	133	47
Kansas River:				
Desoto, Kans	7.4	—	188	107
Mississippi River:				
St. Paul, Minn	7.2	4.3	62	30
Burlington, Iowa	7.3	4.3	47	28
Red River (North):				
Grand Forks, N. Dak	11.3	7.1	72	56

[a] Exceptions:

July-September 1962
Clinch River:
Kingston, Tenn 12.6

October-December 1962
Colorado River:
Page, Ariz 6.9

July-September 1963
Clinch River:
Kingston, Tenn 9.4

October-December 1963
Clinch River:
Kingston, Tenn 6.5

Total beta activity of suspended plus dissolved solids in surface water for the eight selected sampling stations is included in table 3. An increase in beta activity was noted at several of these stations as compared with established background levels. In the sample received from the Big Sioux River the overall increase was large percentagewise, *i.e.* a rise from 120 to 240 pc/liter or 100 percent from June to July 1963. The composite of samples for the month of July 1963 was found to have a beta activity of 130 ± 18 pc/liter of the suspended portion, even though the suspended solids amounted to only 181 mg/liter (*5*). By comparison, in the previous composite (June 1963) the beta activity was 48 ± 15 pc/liter in the suspended portion in which the suspended solids were 153 mg/liter (*6*).

On the Arkansas River at Coolidge, Kansas, two turbid samples showed substantially elevated beta activities; on August 21, 1963, with 3086 mg/liter suspended solids, the beta activity was 771 ± 129 pc/liter, and on September 3, 1963, with 2380 mg/liter suspended solids, the beta activity was 421 ± 108 pc/liter. The other samples collected weekly during these two months were appreciably lower in beta activity as reflected by the quarterly average (*7,8*). The dissolved alpha and beta activities were not significantly different from those commonly observed at this sampling point. Samples from other stations on this river indicated no unusual values. The samples associated with these elevated averages contained large quantities of suspended solids. Thus, only small aliquots could be used in the laboratory determinations in order to avoid excessive self-absorption. In such cases the relatively large multiplication factor, together with the usual range of counting error associated with standard counting periods can result in apparently abnormal levels of radioactivity. The specific activity (pc/g) of the sample discussed above was determined and found to be comparable to the specific activity observed normally in samples from these stations. The apparent increased activity, therefore, may be considered attributable to the extremely high suspended solids content of the samples and is essentially of natural origin.

Summary

Water samples collected during July–September 1963 had appreciably higher levels of strontium–90 than previous quarters. The highest strontium–90 levels were in the north central area of the conterminous States. One of these samples (Red River of the North at Grand Forks, N. D.) contained over 10 pc Sr^{90}/liter. Samples collected during the subsequent quarter (October–December 1963) were found to have lower levels of strontium–90. Relatively higher strontium–90 levels continued to be seen in the north central area.

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Publication in earlier issues of *RHD:*

May 1960
August 1960
November 1960
December 1960
February 1961
June 1961
September 1961
December 1961
February 1962
July 1962
December 1962
March 1963
May 1963
September 1963
January 1964

Section IV—Other Data

RADIOLOGICAL SURVEY OF THE LOWER COLUMBIA RIVER IN OREGON,[1] JANUARY 1962—JULY 1963

George L. Toombs and John G. Bailey[2]

The Lower Columbia River Radiological Survey in Oregon was initiated in June, 1961 and sample collection began in January 1962. The Survey is a joint effort of the Oregon State Board of Health and the Division of Radiological Health, U. S. Public Health Service.[3] The objectives of this survey were: (1) to determine the distribution of radionuclides in environmental media in the Columbia River area below Bonneville Dam and along the Oregon seacoast originating from the Hanford Atomic Products Operation and (2) to develop Oregon State Board of Health Laboratory and staff capabilities for conducting a comprehensive environmental radiation surveillance program.

Hanford is located on the upper Columbia River at Richland, Washington (see figure 1) and consists of a five-hundred square mile complex of nuclear reactors, fuel fabrication plants, chemical separation facilities, and research and development laboratories.

Hanford reactor cooling waters add radioactivity to the Columbia River at a rate of several thousand curies per day. Hanford conducts an extensive environmental radiation sur-

[1] Summarized from original article by Toombs and Bailey (*1*).

[2] Mr. Toombs is Chief Radiochemist and Mr. Bailey is Radiation Health Specialist, Division of Sanitation and Engineering, Oregon State Board of Health.

[3] For other data concerning the Columbia River, see page 386 of this issue.

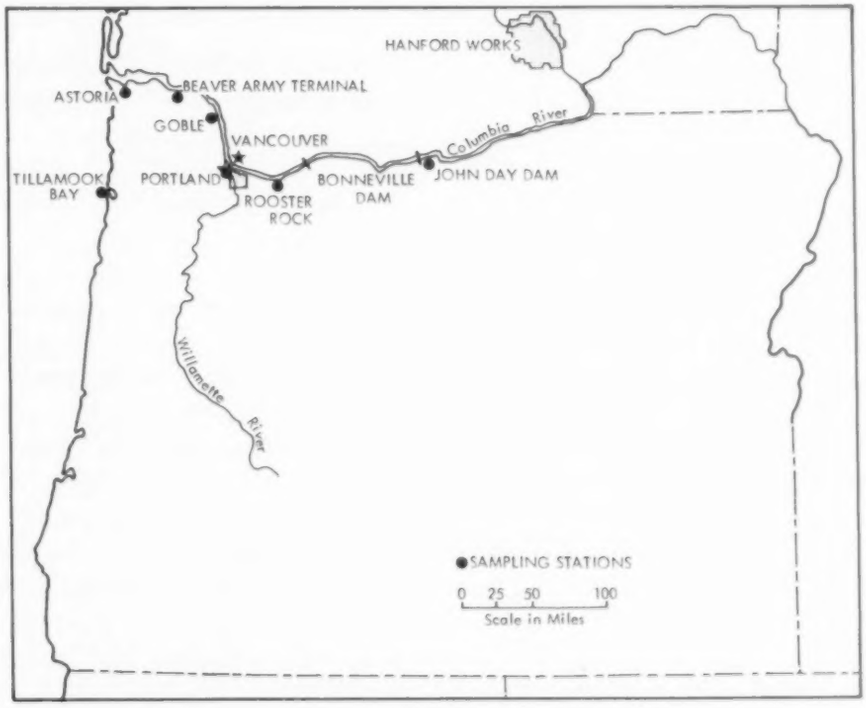

FIGURE 1.—COLUMBIA RIVER STUDY SAMPLING LOCATIONS

veillance program; however, Vancouver, Washington, is the farthest downstream location where river water and biota are routinely sampled. These data together with data on radioactivity in U. S. surface water are routinely published in *Radiological Health Data* (*2,3*).

Sampling Program and Results

The following criteria were used in the selection of sampling locations: (1) availability of samples which could be used to describe the concentrations of the radionuclides present in the environment, (2) accessibility on a year round basis, and (3) avoidance of needless duplication of the sampling efforts of similar programs.

Generally samples were obtained on a monthly basis. Plastic bags were usually used for transportation and storage of all samples except water samples. Most of the biological samples were preserved by refrigeration.

A total of 44 water, 41 sediment, 53 algae, 23 crab, 15 oyster, 25 clam, 8 mussel, 5 sea anemone, and 6 miscellaneous samples were collected and analyzed. Tables 1, 2, and 3 summarize the results from only the primary sampling locations (see figure 1).

Two-liter water samples were collected in polyethylene containers. To prevent plating of the radionuclide onto the container surfaces and to keep dissolved substances in solution, two milliliters of concentrated hydrochloric or nitric acid were added. Table 1 shows the concentration of five radionuclides and total beta

TABLE 1.—SUMMARY OF RADIOACTIVITY IN COLUMBIA RIVER WATER SAMPLES, JANUARY 1962–JULY 1963

[Concentrations in pc/liter]

Location (Columbia River)	Number of samples	Average Minimum-Maximum					
		Beta	K^{40}	Zn^{65}	Zr^{95}—Nb^{95}	Ru^{103}	Cr^{51}
John Day Dam	5	106 100–110	184 <170–581	47 <35–81	<13 <13–15	13 <10–25	3800 2700–5300
Rooster Rock	4	119 54–240	<170 <170–177	45 <35–74	28 <13–91	11 <10–24	2400 1700–3200
Goble	5	41 20–59	<170 <170–338	<35 <35–<35	<13 <13–22	<10 <10–14	1400 930–1800
Beaver Army Terminal	7	91 29–150	<170 <170–241	40 <35–61	<13 <13–19	<10 <10–<10	2000 1300–2600
Astoria	6	65 <10–160	<170 <170–<170	<35 <35–<35	<13 <13–16	<10 <10–13	1400 600–2000
Summary of five locations above	27	84 <10–240	<170 <170–581	<35 <35–81	<13 <13–91	<10 <10–25	2200 600–5300
Other location: Portland (Willamette R.)	9	<10 <10–13	<170 <170–<170	<35 <35	<13 <13–16	<10 <10–<10	<140 <140–<140

TABLE 2.—SUMMARY OF RADIOACTIVITY IN COLUMBIA RIVER SEDIMENT SAMPLES, JANUARY 1962–JULY 1963

[Concentrations in pc/gram wet but drained weight]

Location (Columbia River)	Number of samples	Average Minimum-Maximum			
		K^{40}	Zn^{65}	Zr^{95}—Nb^{95}	Ru^{103}
John Day Dam	8	30.4 11.9–52.0	30.6 1.2–82.1	3.1 0.3–8.9	2.0 0.2–4.5
Rooster Rock	4	12.8 7.0–15.7	0.8 0.2–1.4	4.1 0.7–7.8	1.1 0.3–1.8
Goble	4	31.9 14.5–73.5	64.3 5.2–230	10.9 2.2–35.0	5.4 0.9–17
Beaver Army Terminal	6	33.6 11.5–65.0	56.1 2.2–129	12.2 1.0–27.6	5.5 0.4–13
Astoria	1	28.9	62.9	16.1	6.0
Summary of five locations above	23	27.5 7.0–73.5	42.9 0.2–230	9.3 0.3–35.0	4.0 0.2–17

TABLE 3.—SUMMARY OF RADIOACTIVITY IN ENVIRONMENTAL MEDIA AT TILLAMOOK BAY, JANUARY 1962–JULY 1963

[Concentrations in pc/gram wet weight]

Type of sample	Number of samples	Average Minimum-Maximum			
		K^{40}	Zn^{65}	Zr^{95}—Nb^{95}	Ru^{103}
Water (pc/liter)	7	236 <170–655	<35 <35–<35	23 <13–78	<10 <10–14
Sediment	14	10.3 5.7–18.7	0.6 0.1–1.9	14.5 1.6–51.2	2.7 0.4–7.6
Algae: *Fucus furcatus*	10	7.2 1.4–18.4	0.5 0.2–1.4	8.7 0.9–19.0	2.2 0.1–6.3
Enteramorpha compressa	3	4.5 3.0–5.8	0.4 0.2–0.8	8.0 0.2–19.1	2.5 0.03–4.1
Dungeness Crab	12	2.0 <1.5–3.1	16.7 10.0–27.4	0.4 <0.1–1.4	0.2 <0.1–0.4
Pacific Oysters	13	2.0 1.1–3.1	23.8 7.1–52.0	0.3 <0.1–0.6	0.6 <0.1–0.9
Soft Shelled Clams	16	2.9 1.0–4.1	2.8 1.4–5.3	1.7 0.2–4.4	0.7 0.1–1.6

activity in the Columbia River water at five locations. Also included as an environmental background control are results from the Willamette River at Portland.

Sediment samples were collected by scooping up approximately one liter of the top inch of deposits. These samples were collected from the shallow water along the shoreline, except at Tillamook Bay where the samples were collected on a mud flat which was accessible at low tide. Table 2 summarizes the concentrations of radionuclides in bottom sediment from water sampling locations.

Water and sediment data from all locations have been summarized in row six of both tables. The averages and ranges given here are the totals for all analyses and the averages are obtained by averaging the individual station averages.

Other environmental samples were collected at points along the Oregon coast. Attached algae were picked or scraped from their growing sites and loose algae were hand gathered. Different species were collected and identified but only those collected at Tillamook Bay are reported. One-pound samples of fresh Dungeness crab meat (*Cancer magister*) were purchased from local producers who collect specimens in the sampling locations. One-pint samples of Pacific oysters (*Ostrea gigas*) were purchased from commercial growers who have oyster beds in the sampling locations. Three species of clams were obtained by digging in the mud flat areas at the sampling locations. Table 3 summarizes environmental data from Tillamook Bay, the primary sampling location.

Analytical Procedures

Samples were routinely analyzed within one week after collection. Water, sediment, and algae samples were gamma counted in their original state. The edible parts of crabs, clams, and oysters were counted with tissue liquid. The normal counting period was 100 minutes.

Gamma counting was done with a 3 x 3-inch sodium iodide thallium-activated scintillation crystal. In routine counting 256 channels (10 kev/channel) of a multichannel analyzer were used. Water samples consisting of 1.5 liters were counted in a Marinelli beaker. The counting of the environmental samples was usually performed on 400 ml of sample although 200 ml samples were occasionally used.

Calibration and counting efficiencies for the system were determined by the use of standard sources. To eliminate the contribution to a given photopeak from higher energy interfering radionuclides, Compton scatter corrections were calculated using the data from the standard radionuclide spectra. By approximating the portion of the count rate in the photopeak caused by Compton scattering due to the activity of the higher energy radionuclide, corrections were made for this interference. Corrections for radionuclides not in the analysis scheme

TABLE 4.—MINIMUM DETECTABLE CONCENTRATIONS FOR GAMMA-EMITTING RADIONUCLIDES IN ENVIRONMENTAL MEDIA

Media	Sample size	K^{40}	Zn^{65}	Zr^{95}—Nb^{95}	Ru^{103}	Cr^{51}	Units
Water	1.5 liters	170	35	13	10	100	pc/liter
Other	400 grams	1.0	0.2	0.06	0.04	—	pc/gram

were not made. However, their presence would cause the reported results to be higher than the true values.

The minimum detectable activity was considered to be that amount of activity which in the same counting time gave a count which was different from the background count by three times the standard deviation of the background count. This minimum detectable activity for water and other environmental samples is shown in table 4.

All values are reported as pc/gram wet or drained weight for biological and sediment samples and as pc/liter for water samples. All gamma activity concentrations are extrapolated to the date of collection.

For alpha and beta analyses of water, a 500–ml aliquot of the samples previously gamma–scanned was evaporated to dryness on a 2-inch planchet and counted in a gas-flow internal proportional counter utilizing a two-inch detector. The minimum detectable level for gross beta analyses is approximately 10 pc/liter and for gross alpha analyses is less than 1 pc/liter. Alpha and beta results are not corrected to the time of collection since the concentration of specific alpha- and beta-emitting radionuclides is not known. Due to the high concentrations of dissolved solids, sea water samples were omitted from the alpha and beta analyses.

Discussion

The sources of radioactivity in the areas covered by this survey were the Hanford works located on the upper Columbia River near Richland, Washington; USSR and United States atmospheric weapons testing; and naturally occurring radionuclides, principally potassium–40. Hanford works has eight single-pass production reactors which use treated Columbia River water for cooling. The effluent water from the reactors containing radionuclides is discharged back into the Columbia River. Some twenty radionuclides, formed principally by neutron activation, make up 98 percent of the radioactive material present in the reactor effluent (*4*). These radionuclides are transported approximately 350 miles by the Columbia River to the Pacific Ocean. Most of the Columbia River waters are carried predominantly northward by ocean currents. However, seasonally the Columbia River water flows southward along the Oregon seacoast. The radionuclides which appear as fallout from atmospheric nuclear weapons testing gain access to the Columbia River and Pacific Ocean by direct deposition and surface runoff.

The radionuclide data presented in this report do not represent all of the radionuclides present in the sample. Utilizing gamma spectrometry and half-life decay characteristics, with limited sample preparation, the following radionuclides could be identified in the samples analyzed during this survey: Ce^{141}, Ce^{144}, Np^{239}, Co^{60}, Ru^{103} + Ru^{106}, Ba^{140} + La^{140}, Mn^{54}, Zr^{95} + Nb^{95}, Cr^{51}, Zn^{65}, and K^{40}. The radionuclides Ru^{103} + Ru^{106}, Zr^{95} + Nb^{95}, Cr^{51}, Zn^{65}, and K^{40} could be identified and their concentrations determined with sufficient confidence to warrant reporting. The activation-product radionuclides, Zn^{65} and Cr^{51}, were detected only in environmental samples from the lower Columbia River and Oregon seacoast. The fission product radionuclides, Ru^{103} + Ru^{106} and Zr^{95} + Nb^{95} were detected in all environmental samples with peak values generally observed during the spring of 1963.

Water: Gross alpha concentrations for the Columbia River water samples collected in connection with this survey were all less than 1 pc/liter, indicating the absence of detectable alpha activity.

The gross beta concentrations in the Columbia River water samples were observed to generally decrease with increasing distance from the Hanford reactors. The data tended to confirm the expected decrease in concentrations during the summer months because of high

dilution as the result of the increased summer flows in the Columbia River. Average values for beta activity in water decreased from 106 pc/liter at John Day Dam to 38 pc/liter at Astoria. During a similar time period the average beta activity in the Willamette River at Portland was less than 10 pc/liter.

Generally, concentrations of most gamma-emitting radionuclides in water samples were below the minimum detectable limits of the analytical procedures at all locations sampled below Beaver Army Terminal. The major exception was chromium–51. The average chromium–51 concentration decreased from 3800 pc/liter at John Day Dam to 1400 pc/liter at Astoria. Chromium–51 was not detected in water samples obtained along the Oregon coast or from the Willamette River at Portland. Zinc–65 was usually detectable in water samples from Beaver Army Terminal and other sampling locations upstream. Zinc–65 concentrations in water samples ranged from less than 35 to 81 pc/liter. These results were below maximum permissible concentrations, recommended by the International Commission on Radiological Protection (*5*). For water from all dietary sources, the following ICRP standards are given for the population at large: Zn^{65}, 10,000 pc/liter; Zr^{95}, 20,000 pc/liter; Ru^{103}, 27,000 pc/liter, Cr^{51}, 670,000 pc/liter.

Sediments: Bottom sediments contained comparatively high concentrations of radioactivity. Radionuclide concentrations in the sediment samples collected during this survey showed no trend with respect to distance by water from Hanford reactors. It appears that the radioactivity concentrations observed depends as much or more upon the characteristics of the sediment sampled and sampling technique as it does upon its distance from Hanford. Zinc–65 concentrations in sediment samples from Tillamook Bay remained relatively stable with respect to time at approximately 0.6 pc/gram drained weight. The fission products, zirconium–niobium–95 and ruthenium–103+ 106, reached a definite peak (value) in concentrations during the spring of 1963.

Biological Organisms: These organisms metabolize a wide variety of chemical elements, including the available radioisotopes of the elements. The extent of concentration varies with the organism's requirement for an element, its availability, and chemical form.

Potassium–40 was detected in all of the biological organisms. Potassium–40 has an abundance in natural potassium of about 0.0119 percent. Biological organisms, except for algae, were found to have potassium–40 concentrations of approximately 3 pc/gram weight. Fresh water algae potassium–40 concentrations were about 40 pc/gram wet weight and the marine algae concentrations about 7 pc/gram wet weight.

Zinc–65 was detected in all biological organisms collected from the Lower Columbia River and Oregon seacoast. The observed generalized trend for zinc–65 concentrations with respect to time remained relatively stable in the biological samples collected at the respective locations. The zinc–65 concentrations decreased with distance from the Hanford works. The edible shellfish, oysters and crabs had the highest average concentrations of zinc–65 (about 25 pc/gram wet weight). Soft shelled clams had average concentrations of 3 pc/gram wet weight.

Detectable concentrations of the fission product radionuclides, ruthenium–103 + 106 and zirconium–niobium–95, were also found in the biological organisms. Concentrations of these radionuclides generally reached a peak during the spring of 1963. Average concentrations of these radionuclides in crabs, oysters, and clams were less than 2 pc/gram wet weight.

Although significant concentrations of the radionuclide zinc–65 appeared in oysters and crabs, the amount of zinc–65 consumed by the public from eating these shellfish would be far below the maximum permissible intake. Use of the guides, recommended by the International Committee on Radiation Protection for total body exposure for the general population, implies a permissible intake rate of 8×10^6 pc of zinc–65 per year. The average concentration of zinc–65 was about 25 pc/gram in edible portions of crab and oyster samples collected during this survey. This permissible intake value of 8×10^6 pc would be reached after consuming about 700 pounds of crab and/or oysters per year, or approximately 2 pounds per day over a one-year period.

Conclusions

Concentrations of radionuclides arising from the Hanford reactors and atmospheric nuclear weapons testing were readily detected in the environmental media in the area covered by this survey. Certain trends were generally seen for fission product and activation product radionuclide concentrations. Zinc–65 and chromium–51 concentrations were observed to decrease with increasing distance by water from the Hanford reactors, and to remain relatively stable with respect to time. The fission-product radionuclides, zirconium–niobium–95 and ruthenium–103 + 106, did not show a trend with respect to distance from the Hanford reactors. However, with respect to time, they did show a generalized peak during the spring of 1963, probably due to the heavy fallout accompanying the spring rains. All concentrations for the radionuclides reported were below those recommended by the International Committee on Radiation Protection and Measurements for the general public. The radionuclide concentrations measured during this survey warrant no action other than continued surveillance to insure that the levels of radioactivity in this environment are neither too high nor increasing too rapidly.

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ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required. Summaries of the environmental radioactivity data for 23 AEC contractor installations have appeared periodically in *RHD* since November 1960. Following are reports for Argonne National Laboratory and Savannah River Plant.

Releases of radioactive materials from these plants for the periods covered in the reports below may be compared with standards set forth in the Federal Register, Title 10, Part 20. The appropriate concentration standards are given in table 1. Total alpha data in the Argonne and Savannah reports may be compared with the standards on line 2 in table 1. Total beta activity may be compared with lines 1 and 3. Additionally the Federal Radiation Council daily intake guides for iodine–131, strontium–89, and strontium–90 are noted.

TABLE 1.—CONCENTRATION STANDARDS [a] PERTAINING TO ENVIRONMENTAL MONITORING AT ARGONNE NATIONAL LABORATORY AND SAVANNAH RIVER PLANT

Line No.	Radionuclide or mixture of radionuclides	Environmental MPC's	
		Water	Air
		(pc/liter)	(pc/m ^{3})
1	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, Ra^{223}, Ra^{226}, Ra^{228}, Pa^{231}, and Th-nat are not present [b]	2,000	—
2	Mixtures of unidentified nuclides	10	0.04
3	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{231}, Pu^{241}, Bk^{249} are not present [b]	—	100
4	Barium-lanthanum-140	20,000	4,000
5	Cerium-141	90,000	5,000
6	Cerium-144	10,000	300
7	Cesium-137	20,000	500
8	Cobalt-58	90,000	2,000
9	Cobalt-60	50,000	300
10	Hydrogen-3 (tritium)	3,000,000	500,000
11	Iodine-131 [c]	2,000	300
12	Plutonium-239	5,000	0.06
13	Ruthenium-103	80,000	20,000
14	Ruthenium-rhodium-106	10,000	200
15	Strontium-89 [c]	10,000	1,000
16	Strontium-90 [c]	100	10
17	Thorium-232	2,000	1
18	Thorium-protactinium-234	20,000	2,000
19	Uranium, natural	20,000	2
20	Xenon-133	—	300
21	Zirconium-niobium-95	60,000	1,000

[a] The concentration standards given here were taken from the Atomic Energy Commission's regulation 10CFR, Part 20 (Federal Register, November 17, 1960).

[b] "Not present" implies that the concentration of the nuclide is small (<10%) compared with its appropriate MPC. See Federal Register, Title 10, Part 20, August 9, 1961.

[c] Daily intake guides recommended by the Federal Radiation Council (top of range II) are: iodine-131, 100 pc/day; strontium-89, 2000 pc/day; and strontium-90, 200 pc/day.

1. Argonne National Laboratory
Calendar Year 1963

University of Chicago,
Lemont, Illinois

Air Monitoring

Weekly continuous air filter samples were collected at 7 locations on the Argonne National Laboratory (ANL) site as shown in figure 1 and at 5 offsite locations at Aurora (west of ANL site), Wheaton (northwest), Hinsdale (northeast), Joliet (southwest), and Tinley Park (southwest). The quarterly averages of alpha, beta, and several nuclide concentrations are given in table 2. The radionuclide determinations were made from gamma spectra of monthly composites of the filters. The data show little difference between offsite and onsite measurements for alpha activity and most of the nuclides, inferring that ANL does not contribute detectable quantities of these activities to the atmosphere. The average airborne beta activity during 1963, 5.7 pc/m^3, was approximately 1 pc/m^3 higher than 1962.

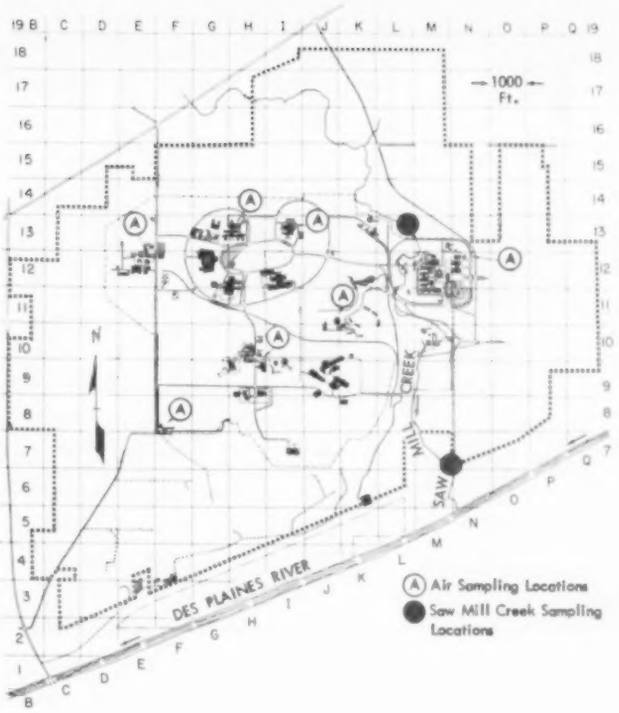

FIGURE 1.—ONSITE SAMPLING LOCATIONS, ARGONNE NATIONAL LABORATORY

TABLE 2.—RADIOACTIVITY OF AIRBORNE PARTICULATES, ANL, 1963

[Concentrations in pc/m^3]

Type of analysis	Sampling locations	1963 Quarterly Averages				1963 Average
		First Quarter	Second Quarter	Third Quarter	Fourth Quarter	
Alpha	On-site	0.0047	0.0064	0.0055	0.0057	0.0056
	Off-site	0.0051	0.0067	0.0055	0.0056	0.0057
Beta	On-site	6.8	9.6	5.0	1.3	5.6
	Off-site	7.1	9.6	4.9	1.3	5.7
Ba-La^{140}	On-site	0.42	<0.01	<0.01	<0.01	0.12
	Off-site	0.38	<0.01	<0.01	<0.01	0.11
Ce^{141}	On-site	0.20	1.5	0.6	<0.5	1.0
	Off-site	0.22	1.3	0.6	<0.5	1.0
Ce^{144}	On-site	1.8	3.7	2.2	0.58	2.1
	Off-site	2.1	4.4	2.0	0.61	2.3
Cs^{137}	On-site	0.06	0.18	0.10	0.03	0.10
	Off-site	0.06	0.20	0.10	0.04	0.10
Ru^{103}	On-site	0.77	0.65	0.16	<0.05	0.41
	Off-site	0.83	0.77	0.16	<0.05	0.45
Ru-Rh^{106}	On-site	0.76	1.9	0.86	0.26	0.93
	Off-site	0.76	2.0	0.78	0.25	0.97
Zr-Nb^{95}	On-site	3.1	4.4	1.50	0.22	2.3
	Off-site	3.2	4.6	1.40	0.21	2.4

Water Monitoring

ANL waste water is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the waste water discharge. Sampling locations on Sawmill Creek and Des Plaines River are shown in figures 1 and 2, respectively.

On Sawmill Creek, weekly grab samples are collected upstream and 3 times a week samples are collected downstream from the waste water outfall. The upstream flow is roughly equal to the waste water flow, yielding a dilution factor of one-half. The data in table 3 show significantly higher concentrations downstream than upstream, an indication of the radioactivity

FIGURE 2.—SITE LOCATION OF ARGONNE NATIONAL LABORATORY (INCLUDING SOME OFFSITE SAMPLING STATIONS)

contributed to the stream by ANL. A comparison of the downstream concentrations with the environmental MPC's listed in table 1 shows that all concentrations are relatively low.

Weekly grab samples are collected from the Des Plaines River upstream and downstream from its junction with Sawmill Creek. The results indicate that the dilution factor of the Des Plaines River is so large that the radioactivity contribution from ANL was not detected.

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*December 1960*
Second quarter 1960	*April 1961*
Third and fourth quarters 1960	*July 1961*
First and second quarters 1961	*December 1961*
Third and fourth quarters 1961	*May 1962*
1962	*May 1963*

TABLE 3.—RADIOACTIVITY IN SAWMILL CREEK, ANL 1963

[Concentrations in pc/liter]

Type of analysis	Sampling location	First half 1963			Second half 1963		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Alpha emitters:							
Total alpha	Upstream	6.5	0.3	1.8	4.1	0.1	1.4
	Downstream	10.1	1.3	3.8	11.8	1.1	4.4
U-natural	Upstream	1.7	0.4	1.1	1.5	0.9	1.3
	Downstream	6.7	0.8	2.5	8.0	1.2	2.8
Pu^{239}	Upstream	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Downstream	0.94	<0.05	0.4	1.2	<0.05	0.27
Th^{232}	Upstream	0.17	<0.05	0.07	0.15	<0.05	0.10
	Downstream	1.0	<0.05	0.19	0.40	<0.05	0.12
Beta emmitters:							
Total beta	Upstream	489	9	84	188	9	31
	Downstream	169	24	68	192	13	38
Co^{58}	Upstream	<5	<5	<5	<5	<5	<5
	Downstream	27.4	<5	6.4	30	<5	6
Co^{60}	Upstream	<2	<2	<2	<3	<3	<3
	Downstream	4	<2	1.0	20	<3	2
Sr^{89}	Upstream	30.3	<2	10.0	18.9	<2	3.8
	Downstream	67.0	<2	9.7	10.1	<2	2.0
Sr^{90}	Upstream	5.3	<0.5	3.0	8.5	1.4	3.1
	Downstream	9.4	<0.05	2.6	7.0	<0.5	1.2
I^{131}	Upstream	<3	<3	<3	[a]—	—	—
	Downstream	45	<3	3.5	78	<3	5
Cs^{137}	Upstream	2.1	<0.5	0.8	<0.5	<0.5	<0.5
	Downstream	10.5	0.6	3.1	5.2	0.8	2.2
Ba^{140}	Upstream	6.6	<2	1.2	<2	<2	<2
	Downstream	20.3	<2	1.4	<2	<2	<2
Th-Pa^{234}	Upstream	1.4	0.3	0.9	1.6	0.7	1.0
	Downstream	5.4	0.6	1.5	5.9	0.6	1.7

[a] Dash means no analysis.

2. Savannah River Plant Calendar Year 1963

E. I. du Pont de Nemours
Aiken, South Carolina

The Savannah River Plant (SRP) maintains a continuous monitoring program to determine the concentrations of radioactive materials in a 1200-square-mile area outside the plant perimeter. Included in this area are parts of Aiken, Barnwell, and Allendale Counties in South Carolina and Richmond, Burke, and Screven Counties in Georgia. This program, initiated in 1951 prior to plant operations, is carried out by the Health Physics Section of E. I. du Pont de Nemours and Company, prime contractor for operation of the plant for the Atomic Energy Commission.

Although SRP discharges some gaseous and liquid waste to the environment, the releases are controlled to assure adequate dispersal so that offsite concentration of radioactive materials is below the Radioactivity Concentration Guides (MPC) shown in table 1. Continuous surveillance of the Savannah River Plant provides information useful both as a measure of the effectiveness of plant controls and as evidence of the strict adherence to the recommended MPC.

Atmospheric Monitoring

Continuous air and rainwater samples are collected at 15 monitoring stations. These stations, which include 5 locations (A–E) at the plant perimeter and 10 locations approximately 25 miles from the center of the plant are spaced so that a measurable plant release of radioactivity to the air would be detected regardless of prevailing wind conditions (see figure 3). Four additional air monitoring stations are

FIGURE 3.—ENVIRONMENTAL SAMPLING LOCATIONS, SAVANNAH RIVER PLANT

operated approximately 100 miles from the plant at Savannah and Macon, Georgia, and Columbia and Greenville, South Carolina (see figure 4). At this distance, the effect of SRP operations is minimal, and therefore, these facilities serve as "reference points" for determining background levels of activity. The complete system of 19 stations permits a comprehensive surveillance of atmospheric radioactivity and differentiation between weapons testing fallout and plant releases. The average concentrations of radioactivity in air are given in table 4.

TABLE 4.—RADIOACTIVITY IN AIR

[Average concentrations in pc/m³]

Period	Source of samples	Alpha	Nonvolatile beta	Iodine-131
First half 1963	Plant perimeter	0.0010	5.6	0.02
	25-mile radius	0.0012	6.2	0.02
	100-mile radius	0.0015	6.2	0.02
Second half 1963	Plant perimeter	0.0011	1.7	<0.02
	25-mile radius	0.0011	1.8	<0.02
	100-mile radius	0.0012	1.8	<0.02

The levels of radioactivity observed in air and in rainwater were attributed to fallout, as the radioactivity concentrations showed no correlation to plant releases.

Milk

Milk samples were collected from dairies and farms within a 50-mile radius of the plant, and were analyzed weekly for tritium and iodine–131 and monthly for strontium–90. Average concentrations for tritium, iodine–131 and strontium–90 are given in table 5.

The estimated exposure to a child's thyroid for calendar year 1963 from consumption of

TABLE 5.—RADIOACTIVITY IN MILK

[Average concentrations in pc/liter]

Analysis (Sensitivity)	Number of Locations	First half 1963	Second half 1963
Tritium (3000 pc/liter)			
Farms	4	5300	[a]—
Local dairies	6	<3900	3600
Major distributors	1	3700	3000
Iodine-131 (2 pc/liter)			
Farms	4	23	[a]—
Local dairies	6	7	<11
Major distributors	1	6	<11
Strontium-90 (1 pc/liter)			
Farms	5	45	[a]—
Local dairies	6	[b] 13	27
Major distributors	3	[b] 19	32

[a] Dash denotes no samples collected.
[b] March 1963.

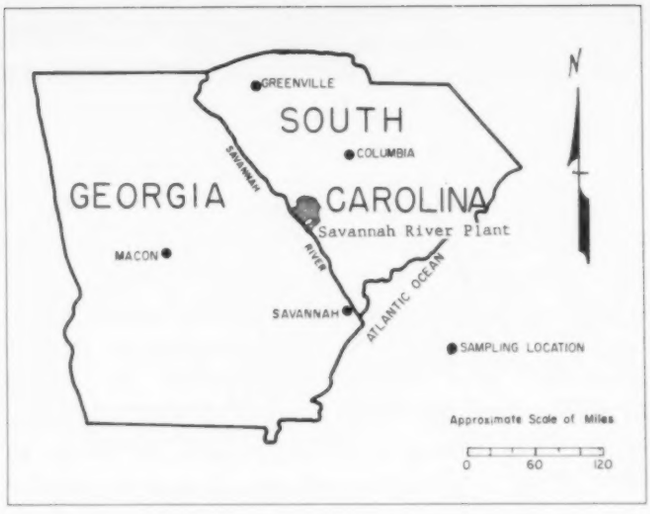

FIGURE 4.—DISTANT AIR MONITORING STATIONS, SAVANNAH RIVER PLANT

one liter of local dairy milk per day was less than 25 percent of 0.5 rem per year guidance value suggested by the Federal Radiation Council. The exposure to an adult would be one-tenth that of a child on a thyroid weight basis.

The higher concentrations of strontium–90 in milk of farm cows were attributed to the feeding habits. These cows generally received little commercial feed but grazed on topshoots or shallow-rooted grasses, both susceptible to fallout contamination. Dairy cows, on the other hand, received less pasture grass and more dried silage and commercial feed. The same relationship seems to be true for tritium and iodine–131.

Vegetation

Bermuda grass, because of its importance as a pasture grass for dairy herds and its year-round availability, was selected for analysis of radioactive contamination.

Average concentrations of alpha emitters and nonvolatile beta emitters found on vegetation collected at the air monitoring locations shown in figure 4 are summarized in table 6.

TABLE 6.—RADIOACTIVITY IN VEGETATION (BERMUDA GRASS)

[Average concentrations in pc/gm]

Period	Source of sample	Alpha	Gamma emitters
First half 1963	Plant perimeter	0.23	689
	25-mile radius	0.21	804
Second half 1963	Plant perimeter	0.14	158
	25-mile radius	0.14	138

Algae and Fish in Savannah River

Determination of radioactivity concentrations in algae is important because algae are concentrators of specific radionuclides and also have an important relationship in the food chain of aquatic organisms. Indigenous algae samples were collected weekly upstream from, adjacent to, and downstream from the plant. The average non-volatile beta concentrations are given in table 7. Some correlation of the plant effluent entry into the river is indicated by the lower upstream values. Fish taken from the river showed negligible plant-contributed radioactivity.

TABLE 7.—NONVOLATILE BETA IN SAVANNAH RIVER ALGAE AND FISH

[Average concentrations in pc/gm]

Period	Location	Nonvolatile beta	
		Algae	Fish (flesh)
First half 1963	Adjacent to plant	165	4
	Upstream (3 mi.)	80	4
	Downstream (10 mi.)	80	5
Second half 1963	Adjacent to plant	150	4
	Upsteam (3 mi.)	60	3
	Downstream (10 mi.)	95	3

Water Monitoring

Communities in the vicinity of SRP obtain water from deep wells or surface streams. Public water samples are collected monthly from 14 surrounding towns. The Savannah River is sampled continuously at 7 locations. Six of the locations are shown in figure 3; the seventh is 60 miles downstream from the plant.

Average concentrations of alpha and beta activity in public and Savannah River water are presented in table 8. The values shown indicate that plant operations contribute small amounts of radioactivity to the Savannah River, and the resulting concentrations are far below MPC.

Specific analyses for certain radionuclides in river water were made for the first time during 1963 by gamma spectroscopy. River water was analyzed previously for iodine–131 by chemical separation. Radionuclides in river water upstream and downstream from the plant during the year are shown in figure 5 and table 9; the values represent the quantities of radionuclides passing the two sample points.

TABLE 8.—RADIOACTIVITY IN WATER

[Average concentrations in pc/liter]

Period	Source of samples	Alpha	Non-volatile beta	H^3	Sr^{90}
First half 1963	Public water supplies	1.4	8	[a]—	—
	Savannah River water				
	3 miles upstream	>0.2	27	600	0.8
	10 miles downstream	>0.2	38	18,000	1.14
Second half 1963	Public water supplies	1.6	8	—	—
	Savannah River water				
	3 miles upstream	>0.2	14	1,200	1.1
	10 miles downstream	>0.2	20	9,600	1.6

[a] Dash indicates no analysis.

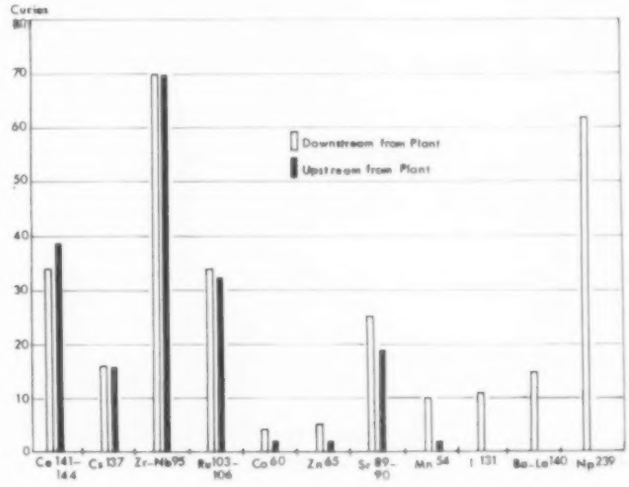

FIGURE 5.—RADIONUCLIDES IN TRANSPORT IN RIVER WATER, JANUARY–JUNE 1963

TABLE 9.—AVERAGE CONCENTRATION OF RADIONUCLIDES IN SAVANNAH RIVER WATER, 1963

[pc/liter]

Radionuclide	Sensitivity of analysis	Control (3 miles upstream from plant)	10 miles downstream from plant
$Ce^{141-144}$	2.5	5.8	6.0
Cs^{137}	0.6	2.8	3.3
Zr-Nb^{95}	0.5	8.0	7.9
$Ru^{103-106}$	3.2	6.5	6.6
Co^{60}	1.4	1.8	2.1
Zn^{65}	1.1	1.6	1.9
Sr^{89}	0.3	3.2	4.6
Sr^{90}	0.01	1.0	1.4
Mn^{54}	0.4	0.7	1.0
I^{131}	0.5	[a]—	2.5
Ba-La^{140}	1.6	[a]—	4.5
Np^{239}	0.9	[a]—	18.0
Cr^{51}	4.3	[a]—	27.0
H^3	600	900	13,800

[a] Less than sensitivity of analysis.

Np^{239}, I^{131}, Ba–La^{140} and Cr^{51} constituted the primary gamma–emitting radionuclides from the plant. These radionuclides, primarily from the reactor areas, decay rapidly after their formation because of their short half lives (<30 days).

Most of the longer lived materials came from fallout.

In no instance was the concentration of any radionuclide in river water more than 4.6 percent of its respective MPC.

External Gamma Radiation Levels

Environmental gamma radiation levels are measured by portable ion chamber dosimeters at each of the 15 air monitoring stations shown in figure 3. The average gamma radiation doses for calendar year 1963 were 0.48 mr per 24 hours at the plant perimeter stations and 0.45 mr per 24 hours at the 25 mile radius stations.

Discussion

During 1963, the levels of radioactivity released to the environs by the SRP were for the most part too low to be distinguished from natural background radiation levels, or were obscured by world-wide fallout from nuclear weapons testing.

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*December 1960*
Second and third quarters 1960	*May 1961*
Fourth quarter 1960	*August 1961*
First and second quarters 1961	*February 1962*
Third and fourth quarters 1961	*September 1962*
Calendar year 1962	*August 1963*

NEVADA TEST SITE—OFF-SITE SURVEILLANCE OF ACCIDENTAL RELEASES, OCTOBER 1962—MARCH 1964.

Atomic Energy Commission[1]

Since the resumption of nuclear testing by the United States, September 15, 1961, the Atomic Energy Commission has announced 122 detonations at the Nevada Test Site through June 30, 1964. Of these 122 detonations, 116 were designed to be contained (eight tunnel experiments and 108 other underground detonations). Ten detonations designed to be contained accidentally released sufficient radioactivity to be measured off the Nevada Test Site and the contiguous Nellis Air Force Range. (Five of these were tunnel experiments.) Only three of these ten detonations occurred in the past eighteen months.

Previous issues of *Radiological Health Data* have contained data on these events up through June, 1962, that have released sufficient amounts of radioactive material to be measured off the Nevada Test Site and the contiguous Nellis Air Force Range. The present report summarizes findings of the U. S. Public Health Service off-site monitoring survey for four of the events since June 1962; i.e., October 19, 1962 (Bandicoot), June 5, 1963 (Yuba), December 12, 1963 (Eagle) and March 13, 1964 (Pike).

Bandicoot

The Bandicoot event was a low yield,[2] underground test detonated October 19, 1962. Airborne radioactivity rose to an altitude of approximately 6,500 feet above the surface. Yucca Weather Station observations at 1100 hours PDT showed the winds in the lower 2,000 feet above the surface to be light and variable with components to the north, east, and south. Winds above this layer were from the north and their speed increased with altitude from 13 to 35 mph up to 12,000 feet above mean sea level (approximately 8,000 feet above the surface).

The lower portion of the cloud which drifted northward was dispersed in the valleys north of the test site. No known exposures to people were involved in the northern off-site segment.

The upper portion of the cloud was carried south from ground zero over Cactus Springs, Indian Springs, and Lathrop Wells, Nevada. The highest instrument reading detected by ground monitors was 20 milliroentgens per hour (mr/hr). This reading was taken seven miles west of the Mercury turnoff on Highway 95 approximately 3½ hours after the detonation. The monitor who measured this dose rate estimated that this dose rate represented peak activity during cloud passage over Highway 95.

[1] This article is presented as a contribution from the U.S. Atomic Energy Commission.

[2] Low yield is defined as less than 20 kilotons.

FIGURE 1.—MONITORING LOCATIONS IN THE VICINITY OF THE NEVADA TEST SITE

The cloud was first detected over Highway 95 approximately two hours after detonation. The highest instrument readings at ground level in populated areas were approximately 0.6 mr/hr at Cactus Springs, Nevada, 36 miles from ground zero, and Ash Meadows, Nevada, 49 miles from ground zero.

Increased gross beta activity was detected on the air filters at nine of the 16 downwind air sampling stations (figure 1) of the Nevada Test Site. Activity was extrapolated to midpoint of collection time. Findings at the highest stations are given in table 1. None of the levels in table 1 represent a measurable dose to the body.

All station film badges and personnel film badges worn by residents in the off-site area indicated below detectable limits; i.e., <30 mr.

The highest levels of iodine–131 found in milk samples collected from stations in the downward area are given in table 2.

Yuba

The Yuba event was a low yield, underground test detonated in a tunnel on June 5, 1963. On the day of the event no radioactivity above background levels was detected in the off-site area by ground or aerial monitoring teams or by air sampling.

TABLE 1.—MONITORING RESULTS AT THE SEVEN STATIONS WHERE HIGHEST READINGS WERE FOUND AFTER BANDICOOT EVENT

[Concentrations in pc/m³]

Station	Collection Period	Gross Beta	Collector [1]	I^{131}	I^{133}	I^{135}
Beatty	1200/19th to 0900/20th	1,050	F	27	D	490
Cactus Springs	1805/19th to 1127/20th	2,300	F	74	D	340
			C	9	46	900
Death Valley Junction	1538/19th to 1630/19th	52,000	F	102	D	345
Indian Springs	1840/19th to 1158/20th	2,300	F	69	D	570
			C	7.2	160	270
Lathrop Wells	1530/19th to 0630/20th	6,700	F	270	D	D
			C	44	D	2,500
Pahrump	1350/19th to 1300/20th	2,000	F	36	D	370
			C	6.2	D	140
Shoshone	1615/19th to 1205/20th	1,040	F	35	D	330
			C	5.2	D	18

[1] F-glass fiber filter; C-Charcoal cartridge; D-detected, but not quantitated.

TABLE 2.—HIGHEST IODINE-131 CONCENTRATIONS IN MILK SAMPLES DOWNWIND OF BANDICOOT EVENT

Station	Date of collection	Iodine-131 concentration [1] (pc/liter)
Barstow, California	10/23/62	130
Barstow, California	11/02/62	110
Barstow, California	11/12/62	20
Springdale, Nevada	10/23/62	160
Springdale, Nevada	10/30/62	140
Pahrump, Nevada	10/23/62	40

[1] Atmospheric tests were being conducted by the United States (Pacific) and the USSR. The iodine-131 content of milk in the U.S. Public Health Service Pasteurized National Milk Network of October 1962, indicated that 12 stations in the U.S. submitted milk samples that were 100 pc/liter or above. The network average for iodine-131 in milk October 1962, for the U.S., was 62 pc/liter. Activity was extrapolated to date of collection.

Monitoring teams entered the tunnel a short time following the Yuba event and determined safe working times for re-entry personnel who were required to recover test data at the earliest possible time after detonation. On the day after the original entry into the tunnel, a release of iodine–131 was detected by radiation monitors who were supporting the data recovery operation. A few days later, a small amount of iodine–131 was also detected on an activated charcoal cartridge of an air filter located at Lathrop Wells, Nevada. The amount was too minute to be quantitated. No unusual levels of gross beta air activity appeared at any of the 32 routine air sampling stations surrounding the Nevada Test Site (to a distance of about 180 miles) following the test.

Eagle

The Eagle event was a low yield, underground test detonated December 12, 1963. Gaseous material that was released following the detonation moved south-southwest from ground zero at a wind speed of approximately 12 mph. The estimated height of the cloud was 1,000 feet above the surface.

All instrument readings obtained by aerial and ground monitors off the Nevada Test Site were essentially background. However, filters and charcoal cartridges on high volume air samplers collected small amounts of short-lived fission products at four of the routine air sampling stations. The highest level of short-lived activity found at any station was 20 pc/m³ of iodine–133 (extrapolated to mid-point of collection) on a filter at Death Valley Junction, California, for a collection period 0930–1550 December 12. (Iodine–131 was not detected.) A charcoal cartridge on an air sampler at the same station collected 15 pc/m³ of iodine–133 for the period 0930–1705 December 12. (Iodine–131 was not detected.)

No fresh fission products (such as iodine–131) were detected in any milk samples.

Pike

The Pike event was a low yield, underground nuclear test detonated March 13, 1964. Shortly after the detonation, radioactivity started escaping from the ground. The winds carried the activity in a southeasterly direction.

The activity was tracked by aircraft southeastward past Las Vegas. A second aircraft, equipped with extremely sensitive instruments aboard, tracked the remaining radioactivity to southern Nevada, Arizona and to a portion of California, adjacent to Arizona. Some spotty patches of activity just above background were

etected in southern Arizona and California. Table 3 gives the highest recorded air filter measurements for populated areas.

TABLE 3.—AIR FILTERS SHOWING HIGHEST ACTIVITIES RELATED TO PIKE EVENT

Station	Collection Period	Gross Beta (pc/m³)	Charcoal Cartridge		
			I-131	I-133 (pc/m³)	I-135
Cactus Springs	0840/13th to 1120/13th	50,000	[a] [b] ND	[b] 700	510
Cactus Springs	1128/13th to 1503/13th	9,000	ND	98	96
Cactus Springs	1505/13th to 1141/13th	23	Trace	4.5	Trace
Indian Springs	0852/13th to 1102/13th	35,000	ND	190	160
Indian Springs	1106/13th to 1530/13th	15,000	ND	123	92
Indian Springs	1530/13th to 1154/14th	42	ND	2.9	ND
Las Vegas	1140/13th to 1445/13th	14,000	ND	60	100
Las Vegas	1450/13th to 1845/13th	680	ND	10	ND
Las Vegas	1850/13th to 2348/13th	59	ND	0.8	ND

[a] ND indicates not detectable.
[b] In addition, the glass fiber filter showed the following values (in picocuries per cubic meter) I-133, 1,000; I-133, 35,000.

The highest potential out-of-door external gamma radiation exposure at populated areas was about 18 milliroentgens at Cactus Springs, Nevada. The next highest was about six milliroentgens at Indian Springs, Nevada, and the third highest was less than one milliroentgen at Las Vegas, Nevada. These values may be compared with the 150–200 milliroentgen annual exposure in these areas from natural background radiation.

Although low levels of radioiodine appeared in some samples of milk from individual farms (table 4), none was found in commercially available milk at any location sampled. All of the cows in the Las Vegas area were on dry feed at this time of year. As an experiment, fresh cut green feed (called green chop) was supplied to six animals selected for experimental purposes at two Las Vegas farms. The highest iodine–131 levels in the milk from the experimental cows fed on green chop peaked at 420 picocuries per liter on March 21, 1964. The levels dropped to 70 picocuries per liter by March 31, 1964. The results of this experiment will be the subject of a separate report.

TABLE 4.—MILK SAMPLES FROM INDIVIDUAL FARMS (EXCEPT FOR THE LAS VEGAS FARMS) THAT SHOWED THE PRESENCE OF IODINE–131 AFTER THE PIKE EVENT [1]

Location	Type	Date Collected	I-131 (pc/liter)
Yuma, Arizona	Raw Milk	17 (AM)	30
Yuma, Arizona	Raw Milk	18 (AM)	50
Yuma, Arizona	Raw Milk	21	80
Yuma, Arizona	Raw Milk	22	60
Yuma, Arizona	Raw Milk	24	40
Yuma, Arizona	Raw Milk	25 (AM)	40
Yuma, Arizona	Raw Milk	26	30
Bard, California	Raw Milk	26 (AM)	50
Blythe, California	Raw Milk	21 (PM)	30
Winterhaven, California	Raw Milk	25 (AM)	40
Winterhaven, California	Raw Milk	26	50

[1] Milk not commercially available.

REPORTED NUCLEAR DETONATIONS, JULY 1964

Two low-yield underground nuclear tests at the Nevada Test Site during July 1964 were announced by the Atomic Energy Commission. These tests conducted on July 16, and 17th were assigned arbitrary *Radiological Health Data* reference numbers 161 and 162, respectively. The former was a United States nuclear test; the latter was a test of a British nuclear device conducted under the Agreement for Cooperation on the Uses of Atomic Energy for Mutual Defense Purposes, which has been in effect between the two countries since August 4, 1958.

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UNITS AND EQUIVALENTS

Symbol	Unit	Equivalent
Bev	billion electron volt	
cpm	count per minute	
dpm	disintegration per minute	
g	gram	
kg	kilogram	1 kg = 1000 gm = 2.2 pounds
km^2	square kilometer	
kvp	kilovolt peak	
m^3	cubic meter	1 m^3 = 1000 liters
ma	milliampere	
mas	milliampere-second	
Mev	million electron volts	
mi^2	square mile	
ml	milliliter	
mm	millimeter	
mrad	millirad	
mrem	millirem	
mr/hr	milliroentgen per hour	
mμc	millimicrocurie	1 mμc = 1 nc
nc	nanocurie	1 nc = 1000 pc = 1 mμc $=10^{-9}$ curies
nc/m^2	nanocurie per square meter	1 nc/m^2 = 1 $m\mu c/m^2$ = 1,000 $\mu\mu c/m^2$ = 1 mc/km^2 = 2.59 mc/mi^2
pc	picocurie	1 pc = 1 μμc = 10^{-12} curies
r	roentgen	
μμc	micromicrocurie	1 μμc = 2.22 dpm

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	ter' a
10^{9}	giga	G	ji' ga
10^{6}	mega	M	meg' a
10^{3}	kilo	k	kil' o
10^{2}	hecto	h	hek' to
10	deka	da	dek' a
10^{-1}	deci	d	des' i
10^{-2}	centi	c	sen' ti
10^{-3}	milli	m	mil' i
10^{-6}	micro	μ	mi' kro
10^{-9}	nano	n	nan' o
10^{-12}	pico	p	pe' co
10^{-15}	femto	f	fem' to

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